

TCM3 and TCM30

Transcutaneous Monitoring Systems

Service Manual

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TCM3 and TCM30 Service Manual

Overview

Introduction

This service manual is to be used as a reference when servicing the TCM3 and TCM30 systems including the various accessories such as recorders, battery cassettes, and mains adapters.

Contents

This service manual contains the following topics.

Topic	See Chapter
Introduction	1
TCM3	2
TCM30	3
TCC3	4
TCR3 and REC	5
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1. Introduction

Overview

Introduction This chapter gives an introduction to the TCM3 and TCM30 monitors. It also gives an overview of the changes and additions to the manual as the front page of all Service Notes are to be inserted here.

Contents This chapter contains the following topics.

Topic	See Page
Overview.....	1
Introduction to the Systems.....	2
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Service Notes

Update of the TCM3/30 Service Manual

In the event of important changes in procedures or components, the Service Manual will be updated by means of Service Notes. Service Notes consists of a front page giving an overview of the changes and copies of revised pages.

The front page should be inserted in chronological order after this sheet whereas the revised pages should be inserted into the Service Manual instead of the existing ones.

Inserted Service Notes

The following Service Notes have already been inserted into the manual.

Part Number	Subject	Issued
917-140	TCM3 electrode socket	8607*
917-141	TCM3 Main PCB	8608*
917-148	TCR3 paper run out	8701
917-156	TCR3 printing voltage	8705
917-157	TCC3 gas inlet module	8707
917-167	TCM3 revision	8803
917-186	Service Manual corrections	8812
917-201	Service Manual updating	8911
917-213	New combined TC-electrode	9003*
917-238	Service Manual updating	9108
917-296	Electrode performance check	9401
917-302	Service Manual updating	9405
917-334	CE labelling - New parts	9601
N/A	Introduction of TCM30	9706
917-352	Service Manual updating	199808-1

SERVICE NOTES

from Radiometer Medical A/S

917 - 334

Analyzer: TCM3

January 3, 1995

Subject CE Labeling - New Parts

Background In connection with the CE labeling of the TCM3 system, some changes to the hardware have been implemented to improve the EMC (Electro Magnetic Compatibility).

Implementation These changes are implemented in: TCM3s of Run 148 onwards,
REC3s of Run 69 onwards, and
E5280 of Lot LR # onwards.

Please note that TCM3s of Runs 146 and 147 include all the changes for compliance with the CE labeling (only the CE label itself is missing)

No hardware changes are required for the TCC3 and the BAT3.

They are CE labeled as of Runs 102 and 17 respectively

BAT3 R0015N005 is also CE labeled.

Changes *The following new part has been introduced:*

902-428 Analog PCB for the TCM3 (revised layout)

The following three parts have been modified:

901-832 Power Supply PCB for the TCM3 (decoupling capacitors added)

901-806 Printer Control PCB for the REC (ground strap changed)

945-377 E5280 to pO_2/pCO_2 Electrode (decoupling capacitors added)

Modified PCBs which retain the original part numbers are marked with a round blue label on the box.

On new E5280 electrodes, one half of the type marker is green and the other half is white (both halves of the earlier type marker are green).

Procedures The new and modified PCBs MUST be used for servicing TCM3s of Run 148 onwards and RECs of Run 69 onwards to maintain compliance with the CE labeling.

The new parts should also be used for servicing TCM3s of Runs 146 and 147. Earlier analyzers may be serviced with the original parts.

IMPORTANT: A TCM3 system will comply with the CE labeling only when ALL of its components (TCM3, REC, and E5280) are of the CE labeled version.

Service Notes for TCM3 and TCM30 Service Manual

Introduction

The service manual has been updated in the following respects:

- A sheet which may be used for documenting the results from an Electrode Performance Check has been included in the appropriate sections.
The procedure and the documentation of results is to be carried out in connection with a service action which may affect measuring performance.
 - In the Checkout and Adjustment sections information about where the monitor is to be dismantled has been included.
 - A number of typographical errors have been corrected.
-

Documentation

Please replace the following existing sheets with the ones supplied with this Service Note.

- Inner front page
- Pages 1-3, Service Notes
- Section 2, entire section (text only)
- Section 3, entire section

Finally the following diagrams should be inserted at the end of section 2 (behind the existing diagrams):

28622-A4

7422-A3

7427-A3

28623-A4 and

28455-A4

Issue

917-352, 199808-1

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2. TCM3

TCM3

Introduction This part gives detailed information about the function and servicing of the TCM3 monitor.

Contents This chapter contains the following topics.

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Dismantling and Replacements.....	2-35
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General Information

Overview

Introduction This section gives some general information about the TCM3 monitor.

Contents This section contains the following topics.

General Information 2-4

General Information

Introduction

The TCM3 combined pO_2/pCO_2 monitor is intended for transcutaneous monitoring of pO_2/pCO_2 via a heated electrode mounted on the skin. The measurement data are presented on the LED display and printed by the optional TCR3/REC digital recorder via the serial data output socket.

The monitor is fitted with a rechargeable NiCd battery. When fully charged, its capacity correspond to approximately three hours of operation.

A mains adapter charges the NiCd battery and supplies the monitor simultaneously. A discharged NiCd battery is recharged in approximately 16 hours when the monitor is switched on during charging. If not, 8 hours is required for a full recharge.

The serial data or analog outputs are functional only if the monitor is powered from the mains.

If an optional battery cassette is connected to the monitor, its total capacity corresponds to approximately 11 hours of operation.

TCM3 from R22 onwards include the following features:

- 4 channel analog output (pO_2 , pCO_2 , heat/temperature, alarm)
- Trend memory for up to 12 hours patient data collection
- The optional digital recorder REC is powered from TCM3

The monitor cabinet is designed for attaching the optional recorder or battery cassette to the monitor

TCM3 below R22 does not include the trend memory feature nor the recorder/battery cassette attaching feature.

Their analog output has only 2 channels (pO_2 and pCO_2) and the monitor is powered from the optional digital recorder TCR3.

Software

The monitor is microcomputer controlled, and the software primarily takes care of the following functions:

- Measurement of the primary electrode parameters and conversion into pO_2/pCO_2 (mmHg or kPa)
 - Measurement of the electrode temperature and heat control
 - Data transfer to the display and the serial data/analog outputs
 - Activation of the acoustic alarm where the pO_2/pCO_2 , heat or temperature parameter limits are exceeded
 - Front panel keyboard control
 - Automatic calibration and electrode check
-

Continued on next page

General Information, *Continued*

Hardware

The electronics are mounted on four PCBs. Please refer to the block diagram at the end of the TCM3 part.

Monitor	Drawing
TCM3 below R22	3759-A2, revision 0
TCM3 from R22	3759-A2, revision 1

Analog PCB

This board includes the electrode input circuits, the A/D converters, the patient safety barrier components and the charging circuit for the NiCd battery.

Signals from the electrode and the electrode amplifiers mounted in the electrode plug, that is, the pO_2 , pCO_2 and thermistor signals, are converted into pulse signals by the two A/D converters. The pulse duty cycle represents the measured value.

One of the A/D converters is common to all parameters via the input multiplexer. The other is used in order to increase the speed and security of the electrode temperature regulation system.

The electrode temperature is measured by means of a thermistor which is part of a temperature resistor bridge.

The heat power is measured across the resistor R, and the microcomputer is informed via the input multiplexer and A/D converter 1.

The NiCd battery charging circuit adjusts the charging current according to the monitor consumption.

The galvanic separation between the power supply board and the rest of the monitor is achieved by using a switching power supply, and opto-couplers for the input/output signals.

TCM3 below R22 include two opto-couplers. One for digital/analog output and one for digital input.

TCM3 from R22 onwards includes five opto-couplers. Two for the input/output, and two for automatic power supply regulation.

The fifth opto-coupler is transferring on/off information from the on/off switch to a switching circuit, which prevents the optional battery cassette from being discharged, if it is not dismantled after use.

Continued on next page

General Information, *Continued*

Main PCB

Includes the microcomputer system, the parallel and serial input/output ports, the electrode heating supply, the 5 V supply and the LED display control system.

The two parallel ports interface the microcomputer with the analog signals, the front panel keys and the heat control.

TCM3 below R22 include a DIP switch for setting some user-selectable options.

Switch	Function
1	ON: mmHg, OFF: kPa
2	ON: In-vivo cal. (not approved by the FDA)
3-7	Not used
8	ON: Demonstration mode. The time-out functions in the Setup and AUX programs are cancelled.

TCM3 of R22 onwards do not include the DIP switch. Instead, the options are selected via the front panel keys.

A demonstration mode is called by switching on the monitor while pressing the ALARM-OFF key and the ▲ key simultaneously. In this mode, the time out in the Setup and AUX programs, are cancelled for 30 minutes after power on.

To get back to normal, switch off and on the monitor.

Selection between mmHg and kPa, and in-vivo cal, are performed while the monitor is in service mode step 4.

Switch on the monitor while the ALARM OFF key and the SET key are pressed simultaneously. The software version No. is displayed in the AUX display. Wait until the software No. stops flashing and select step 4 (0:04 in the AUX display) by the ALARM-OFF key.

Now, selection between mmHg and kPa are performed by the ▲ or ▼ keys. kPa "mode" is indicated by decimal points in the pO_2 and pCO_2 displays.

Selection between in-vivo cal. and not in-vivo cal. is performed by the CAL key. In-vivo cal. "mode" is indicated by the AUX display.

The UART controls the serial input/output signals for the serial data interface. The output signal is gated with the analog control signal from Port 1.

The heat supply is derived via a D/A converter and a switching power supply. It is controlled by the heat-off signal and the max. temperature monitoring circuit, the so-called "watch-dog" circuit, which disables the heat in the case of a software error.

The Main PCB includes a power supply monitoring system for activating the BAT light-bar or resetting the monitor.

Continued on next page

General Information, *Continued*

Main PCB (continued)

If the monitor is powered from the built-in NiCd battery only, the light-bar is activated via comparator 1, indicating that the function time of the Monitor is limited to approximately 3 hours on a fully charged battery.

The heat supply circuit has a battery-low terminal which is activated if the NiCd battery voltage drops below 7.0 V. This causes the BAT light bar to flash, indicating that the function time now is limited to approximately 10 minutes.

If the voltage drops below 6.5 V, the microcomputer and its peripherals will be reset.

The microcomputer system consists of the 8-bit CMOS processor NSC 800, the EPROM (program memory), the RAM (data memory) and the input/output peripherals already mentioned. The system has a multiplexed bus structure where the low order part of the address bus is shared with the data bus.

The display is multiplexed and the 7-segment display data are latched from the data-bus.

Display PCB

Includes the LED display, the audio transducer for the acoustic alarm, the electrode holder micro-switch and the 5 front panel keys. If the mains adapter is removed from the monitor, the display light is reduced. This reduces the power consumption and thus prolongs the function time of the monitor.

Power Supply

The circuits of this PCB are galvanic isolated from the rest of the monitor by means of the transformer and opto-couplers on the Analog PCB. It includes a switching regulator power supply system, 3 linear DC regulators and a communication circuit for the analog output and serial data input/output.

The switching regulator has a combined current limiter/battery control circuit which disables the regulator output if the battery voltage decreases below 6.2 volts.

Continued on next page

General Information, Continued

Patient Safety TCM3 is designed to comply with the IEC safety standards for medical equipment.

Any external device connected to the monitor, such as mains adapters, recorders, computers etc., are galvanic isolated from the patient circuits.

The isolation is achieved by means of opto-couplers and a switching transformer.

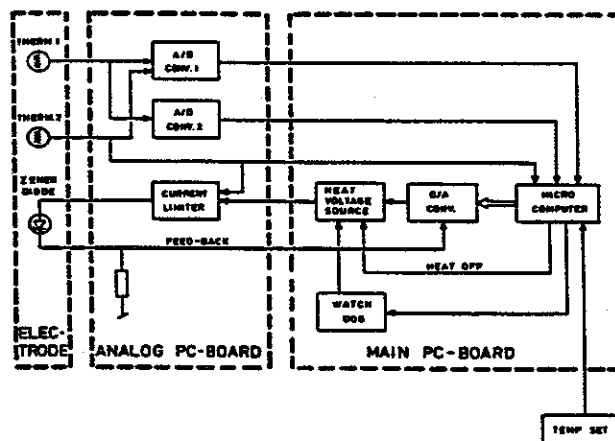
The "patient-side" of this barrier thus includes the Analog PCB, the Main PCB, the Display PCB and the NiCd battery.

Each individual monitor is exposed to a final safety test before it leaves RADIOMETER for shipment.

This safety test includes a patient barrier isolation test by a high voltage generator, and a leakage current test.

The monitors are fitted with a comprehensive safety system to minimise the probability of losing electrode heat control.

- The electrode power consumption is continuously monitored. If it exceeds 600 mW for more than two minutes, the heating will be switched off and Error 5 will be displayed.
- If the electrode temperature increases to more than 45.6 °C, the heating will be switched off, and Error 10 is displayed. Further, the heat regulator will be disabled.
- If a temperature difference of more than 0.6 °C is detected between the two thermistors (combined electrodes E5277 and E5280) the heating will be switched off and Error 11 is displayed.
- If a software error occurs, a monitoring circuit, the so-called "watchdog" circuit, on the Main PCB will switch off the heating.



Continued on next page

General Information, *Continued*

Specifications

Environmental Requirements

Ambient temperature: 5 - 40 °C. *)

Relative humidity: 20 - 80 %.

*) If the electrode temperature is below 15 °C before calibration, the monitor may signal Error 1, indicating that the electrode did not reach the pre-set temperature within 3 minutes.

Calibrate then the monitor in two steps:

Calibrate with the temperature pre set to 37 °C. Repeat the calibration with the temperature pre set to the actual monitoring temperature.

Ventilation Requirements

The system must be situated in a well ventilated, dust free atmosphere.

Dimensions

Height (cm) 8

Width (cm) 24

Depth (cm) 26

Weight (kg) 2.7

Units

The monitor can be set-up so as to indicate the O₂/CO₂ tension in either mmHg or kPa directly.

Monitor Battery

Rechargeable NiCd battery. The duty period is 3 hours per charge, typically, at 25 °C.

The recharging time is approximately 8 hours at 25 °C, via the mains adapter.

Monitor pO₂ channel

Range: 0 - 800 mmHg or 0 - 99.9 kPa

Accuracy: Better than ± 1 mmHg/0.1 kPa ± 0.1 % of reading at 25 °C.

Polarisation Voltage: -680 mV

Continued on next page

General Information, *Continued*

Specifications (continued)

Monitor pCO₂ channel

Range: 5 - 200 mmHg or 0.7 - 26.7 kPa.

Accuracy: Better than ± 1 mmHg/0.1 kPa ± 0.1 % of reading at 25 °C.

Electrode Heat

Range: 0 - 600 mW ± 10 % of reading.

Temperature Settings

37.0 °C, 41.0 °C, 41.5 °C, 42.0 °C, 42.5 °C, 43.0 °C, 43.5 °C, 44.0 °C,
44.5 °C, 45.0 °C.

Accuracy: Better than ± 0.1 °C excluding sensor.

Alarms

Audio visual. The acoustic alarm will be activated after a delay of 5 seconds when an alarm state has occurred.

pO₂ alarm limits: (selected by user) LOW: 0 - 99 mmHg/0 - 9.9 kPa
HIGH: 0 - 800 mmHg/0 - 99.9 kPa

pCO₂ alarm limits: (selected by user) LOW: 0 - 99 mmHg/0 - 9.9 kPa
HIGH: 0 - 200 mmHg/0 - 26.7 kPa

Temperature: ± 0.3 °C deviation from preset value will cause alarm.

Battery low: Alarm goes on before the battery is empty

Leakage Currents

Enclosure Leakage Current: Max. 100 uA

Patient Leakage Current: Max. 10 uA

Continued on next page

General Information, *Continued*

Specifications (continued)

Serial data output

Signal	Connector Pin
TX data	11
RX data (normally not used)	14
Common Return	15

Transfer parameters

2400 baud

7 bits/character

Odd parity

2 stop bits

Analog outputs

Channel/ Connector	Parameter	Output
1 / pin 9	pO_2	5 mV/mmHg (40 mV/kPa) or 1 mV/mmHg (10 mV/kPa) (selected in the AUX program 200/800 mmHg or 25.0/99.9 kPa)
2 / pin 10	pCO_2	10 mV/mmHg (100 mV/kPa) or 5 mV/mmHg (40 mV/kPa) (selected in the AUX program 100/200 mmHg or 10.0/25.0 kPa)
3 / pin 8	Heat/temp.	Heat: mW is converted to mV. Temperature: 50 mV/°C, range 30 °C to 50 °C. Examples: 30 °C gives an output of 0 mV. 43 °C gives an output of 650 mV
4 / pin 5	Alarm	Acoustic alarm activated: 1000 mV Acoustic alarm not activated: 0 mV Max. source current: 1 mA
-- / pin 15	Common return	

Test Procedures

Overview

Introduction This section details the procedures for testing and adjusting the TCM3 monitor. For each of the paragraphs the required tools for testing are listed.

Contents This chapter contains the following topics.

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Introduction

Checkout and Adjustment

This Section describes the necessary procedures for checking and adjusting the TCM3.

For TCM3 with serial nos. from 101R22N01 onwards, some test procedures differ considerably from the procedures for the TCM3 below RUN 22.

Yearly Maintenance

RADIOMETER recommends a yearly preventive maintenance checkout which includes:

Checkout and Adjustment.

Monitor Performance Check.

These procedures are outlined in the following two paragraphs.

Repairs

Repairs to TCM3 are made only by replacing defective PCBs, which are returned to RADIOMETER for exchange. This is to ensure patient and functional safety.

Checkout and Adjustment

Introduction

To carry out the checkout and adjustment procedure, the following accessories are necessary:

- TC-Electrode Simulator, code 901-705 as described in Chapter 6 of the Service Manual, ACCESSORIES.
- 4 1/2 digit Digital Voltmeter, (the Fluke 8060A or similar is recommended). Please note that checkout and adjustment of the 5 V reference voltage requires a 5 1/2 digit instrument.
- Electrode Control Cable for TC Electrode Simulator. Code 617-854.
- Output Control Cable for TC Electrode Simulator. Code 617-855.
- Variable Power Supply, 0 - 12 VDC, 1 A.
- Adjustment tool for the trimming potentiometers.

The internal battery should be well charged when carrying out the procedures.

Please note that some steps require the cabinet to be opened. When carrying out all procedures, the cabinet should be opened before initiating the first procedure.

The procedures are based on the built-in test program.

The test program is called by switching on the monitor while the electrode simulator is connected to the monitor with the ELECTRODE switch set in the TEST position.

Without the simulator, the test program can be called by switching on the monitor while pressing the ALARM OFF and SET keys simultaneously.

The test software includes 20 program steps. The actual test mode number is displayed in the auxiliary display (except steps 1 and 5).

The pO_2/pCO_2 displays function as a Digital Voltmeter in step 8 - 11.

The ALARM OFF key is used to step through the test program. The stepping direction can be reversed with the SET key (except in step 2).

Self-test

This procedure checks the RAM, EPROM, and peripherals.

Step	Action
1.	Connect the TC Electrode Simulator to the monitor with the two control cables.
2.	Set the simulator ELECTRODE switch to TEST and switch on the monitor. All display segments, light-bars and the audio alarm will be activated for 2 seconds. The auxiliary display will show the software version number (the first 10 seconds flashing).
3.	Press the ALARM OFF key to advance the test program.

Continued on next page

Checkout and Adjustment, *Continued*

Display PCB

The following steps are carried out to check the keys and display segments.

Step 0:02

Step	Action
1.	Press the SET key. The AUX display and its light-bars will be activated.
2.	Press the ▲ key. The pO_2 display and its light-bars will be activated.
3.	Press the CAL key. The pCO_2 display and its light-bars will be activated.
4.	Press the ▼ key. The audio alarm steps through all levels.

Step 0:03

The following steps are carried out to check the electrode holder micro-switch and the reading of the electrode code.

Step	Action
1.	Electrode holder micro-switch out: 111 in pCO_2 display. Electrode holder micro-switch in: 000 in pCO_2 display.
2.	Simulator ELECTRODE switch pos. pO_2 display pO_2/pCO_2 000 pCO_2 111 pO_2 222 TEST 333

DIP Switch

These steps are carried out to check that the DIP switches are read correctly (TCM3 monitors below RUN 22 only).

Step 0:04

The DIP switch code is shown in the pCO_2 display as a hexadecimal number.

Step	Action
1.	Note the DIP switch setting.
2.	Check that the number is 00 if all 8 switches are in pos. ON and FF if they all are in pos. OFF.
3.	Set the DIP switch as it was before the check.

Continued on next page

Checkout and Adjustment, *Continued*

In-vivo cal. /mmHg - kPa

Step 0:04

TCM3 Monitors from RUN 22 onwards do not include the DIP switch. Instead, the functions are selected from the front panel. These steps are carried out to check that the selection is possible.

- | Step | Action |
|------|--|
| 1. | Switch between mmHg and kPa by the ▲ or ▼ key. When in kPa mode, the monitor displays decimal points in the pO_2 and pCO_2 displays. |
| 2. | Switch between in-vivo cal and not in-vivo cal by the Cal key. The AUX. display indicates in-vivo cal. |
| 3. | Ensure that the monitor settings are correct before continuing with the next step. |

Please observe that in-vivo cal. is not approved by the FDA in the USA.

Power Supply

The following procedures are carried out to check the Power Supply.

The procedures require the cabinet to be opened.

Please note that two different procedures are included, one for TCM3 monitors below RUN 22 and one for TCM3 monitors from RUN 22 onwards.

TCM3 monitors below RUN 22:

- | Step | Action |
|-----------|---|
| Step 0:05 | 1. Entire display is lit ("0:05" is not shown in AUX display).
Connect 9 VDC (external power supply) to the simulator terminal DC INPUT. Check that the secondary voltage of the switching transformer is 8.00 ± 0.15 V (DVM+ to TP7, DVM- to TP8 on the Analog PCB).
If outside, adjust R33 on the Power Supply PCB for 8.00 ± 0.05 V. |
| Step 0:06 | 2. Disconnect the external power supply from the simulator.
Connect the monitor to the mains by means of the Mains Adapter. |
| | 3. Check the above voltage for 9.20 ± 0.2 V. |
| Step 0:07 | 4. Connect DVM+ to TP3 and DVM- to TP4 on the Main PCB and check that the voltage is 5.000 ± 0.003 V (+5V).
If outside, adjust R53 on the Main PCB for 5.000 ± 0.001 V. |
| | 5. Connect DVM+ to TP 8 and DVM- to TP 4 on the Main PCB and check that the voltage is 5.00 ± 0.1 V (+ 5V RAM). |

Continued on next page

Checkout and Adjustment, *Continued*

TCM3 monitors from RUN 22:

	Step	Action
Step 0:05	1.	Entire display is lit ("0:05" is not shown in AUX display). Connect 12 VDC (external power supply) to the simulator terminal DC INPUT. Check that the secondary voltage of the switching transformer is 8.20 ± 0.15 V (DVM+ to TP7, DVM- to TP4 on the Analog PCB).
Step 0:06	2.	Disconnect the external power supply from the simulator. Connect the monitor to the mains by means of the Mains Adapter.
	3.	Check the above voltage for 9.20 ± 0.2 V.
Step 0:07	4.	Connect DVM+ to TP5 and DVM- to TP4 on the Analog PCB and check that the voltage is 5.000 ± 0.003 V (+5V). If outside, adjust R53 on the Main PCB for 5.000 ± 0.001 V.
	5.	Connect DVM+ to TP 8 and DVM- to TP 4 on the Main PCB and check that the voltage is 5.00 ± 0.1 V (+ 5V RAM).

pO₂ Channel This procedure checks the polarisation voltage and zero-point for the *pO₂* channel.

	Step	Action
Step 0:09	1.	Check that the polarisation voltage reading in the <i>pO₂/pCO₂</i> display is between 0.6 77.0 and 0.6 83.0 (-677.0 to -683 mV).
Step 0:08	2.	Connect the simulator TEST SOURCE -680 mV terminal to the TEST INPUT <i>pO₂</i> terminal and check that the <i>pO₂</i> display shows the same value as for the polarisation voltage ± 0.5 mV (Step 0:09).

In step 0:10 the display shows the voltage applied to the TEST INPUT *pO₂* terminal minus the polarisation voltage obtained in step 0:09. This facility is, however, not used in the checkout and adjustment procedures.

Continued on next page

Checkout and Adjustment, *Continued*

pCO₂ Channel This procedure checks the zero-point and gain for the pCO₂ channel.

	Step	Action
Step 0:11	1.	Connect the simulator TEST SOURCE +1 mV terminal to the TEST INPUT pCO ₂ terminal and check that the pCO ₂ display shows 01.0 ± 01.0 (1.0 ± 1.0 mV). If necessary, adjust R88 (TCM3 RUN 22 onwards only) on the Analog PCB to 1.0 ± 1.0 mV. Note the deviation.
	2.	Connect the simulator TEST SOURCE + 185 mV terminal to the TEST INPUT pCO ₂ terminal and check that the pCO ₂ /pO ₂ display reading is 0.1 85.0. <u>The deviation must be less than ± 0.0 00.5 when compensated for the zero-point error.</u> Example: The pCO ₂ zero point error is measured to be 0.2 mV. The gain value then must be between 184.7 and 185.7 mV.

Temperature Channel 1

This procedure checks the zero-point and gain for the temperature channel 1.
The procedures require the cabinet to be opened.

	Step	Action
Step 0:12	1.	Set the simulator TEMPERATURE switch to 37 °C and the THERMISTOR switch to SINGLE . Check that the display shows 36.985 and 37.015 (zero-point). If outside, adjust R17 on the Analog PCB to a reading between 36.997 and 37.003.
	2.	Set the simulator TEMPERATURE switch to 45 °C. Check that the display reading is between 44 985 and 45 015 (gain). If outside, adjust R20 on the Analog PCB to a reading between 44 995 and 45 005. Readjust R17 and R20.
Step 0:14	3.	Set the simulator TEMPERATURE switch to 37 °C. Check that the display reading is between 36 900 and 37 100.
	4.	Set the simulator TEMPERATURE switch to 45 °C. Check that the display reading is between 44 900 and 45 100 (thermistor 1 via the MUX).

Continued on next page

Checkout and Adjustment, *Continued*

Step 0:14
(continued) If the readings in step 0:14 are not within the stated ranges, repeat the adjustments in step 0:12 and repeat the checks in step 0:14.

If the readings in step 0:14 are still outside the range, the Analog PCB is defective and must be replaced.

Temperature Channel 2

This procedure checks the zero-point and gain for the temperature channel 2.

The procedures require the cabinet to be opened.

Step	Action
------	--------

Step 0:13

1. Set the simulator THERMISTOR switch to DOUBLE.
2. Set the simulator TEMPERATURE switch to 45 °C.
Check that the display shows 44 965 and 45 035 (zero-point).
If outside, adjust R26 on the Analog PCB to a reading between 44 995 and 45 005.
3. Set the simulator TEMPERATURE switch to 37 °C.
Check that the display reading is between 36 965 and 37 035 (gain).
If outside, replace the Analog PCB.

Heat Regulator

This procedure checks the regulator for heating the electrode.

Step	Action
------	--------

Step 0:15

1. Set the simulator THERMISTOR switch to DOUBLE and the TEMPERATURE 37 °C.
2. Connect the DVM+ to simulator HEAT- and DVM- to HEAT+ and check that the voltage is between -11.8 and -14.2 V (electrode voltage, max. heat).
3. Move the DVM+ to simulator GND and check that the voltage is 1.00 V +/- 0.05 V (electrode current, max. heat).
4. Set the simulator TEMPERATURE to 45 °C and check that the voltage is less than 0.05 V (electrode current, min. heat).
5. Set the simulator TEMPERATURE to 46 °C and check that the voltage is less than 50 mV (max. temp.).

If the DVM readings in step 0:15 are not within the stated tolerances, check the heat supply circuit on the Main and Analog PCBs, and replace the defective PCB.

Continued on next page

Checkout and Adjustment, *Continued*

Analog Outputs For checking the analog outputs, the procedure to be used depends on the serial number of the monitor. For both procedures the following apply:

The procedures require the cabinet to be opened.

Connect the monitor to the mains via the Mains Adapter. Set the Simulator OUTPUT switch to ANALOG.

Allow in each step the analog output to stabilise (approximately 30 seconds) before reading the DVM.

TCM3 below RUN 22:

	Step	Action
Step 0:16	1.	pO_2 zero-point, 0% modulation. Connect DVM+ to simulator pO_2 ANALOG OUTPUT and DVM- to COM. Check that the output is -107.5 ± 3.0 mV. If outside, adjust R84 on the Power Supply PCB to -107.5 ± 1.0 mV.
	2.	pCO_2 zero-point, 0% modulation. Connect DVM+ to simulator pCO_2 ANALOG OUTPUT, and DVM- to COM. Check that the output is -107.5 ± 3.0 mV. If outside, adjust R86 on the Power Supply PCB to -107.5 ± 1.0 mV.
	3.	pO_2 gain, 40.23% modulation Connect DVM+ to simulator pO_2 ANALOG OUTPUT, and DVM- to COM. Check that the output is $+1000.0 \pm 3$ mV. If outside, adjust R83 on the Power Supply PCB to 1000.0 ± 1.0 mV.
	4.	pCO_2 gain, 40.23% modulation. Connect DVM+ to simulator pCO_2 ANALOG OUTPUT, and DVM- to COM. Check that the output is $+1000.0 \pm 3.0$ mV. If outside, adjust R85 on the Power Supply PCB to 1000.0 ± 1.0 mV.
Step 0:17		
Step 0:18	5.	pO_2/pCO_2 zero output, 3.91% modulation. Check that the two simulator ANALOG OUTPUTs are 0.0 ± 5.0 mV.

Continued on next page

Checkout and Adjustment, *Continued*

Analog Outputs *TCM3 from RUN 22:* (continued)

	Step	Action
Step 0:16	1.	All channels, 0% modulation Check that the output from all 4 channels (pO_2 , pCO_2 , 3 and 4) are -109.0 ± 5.0 mV. If outside, adjust the pO_2 channel (by R48 on the Power Supply PCB) to -109.0 ± 1.0 mV. Check that the other 3 channels are -109.0 ± 5.0 mV.
Step 0:17	2.	All channels, 20.12% modulation Check that the output from all 4 channels (pO_2 , pCO_2 , 3 and 4) are 1000.0 ± 15.0 mV. If outside, adjust the pO_2 channel by R67 on the Power Supply PCB to 1000.0 ± 1.0 mV. Check that the other 3 channels are 1000.0 ± 15.0 mV.
Step 0:18	3.	All channels, 1.95% modulation Check that the output from all 4 channels (pO_2 , pCO_2 , 3 and 4) are 0.0 ± 5.0 mV.

If the tolerances in step 0:16, 0:17, or 0:18 are exceeded after the above adjustments have been performed, the Power Supply PCB is defective and must be replaced.

Max. Temp. Watchdog

This procedure checks the Max. Temp. Watchdog. In this step the CPU does not trigger the watchdog for which reason the heat is turned off.

Step 0:19

Step	Action
1.	Simulator TEMPERATURE 37 °C. Connect DVM- to simulator HEAT+ and DVM+ to GND. Check that the voltage is less than 0.050 V.

Continued on next page

Checkout and Adjustment, *Continued*

Serial Data This procedure checks the serial output via a loop-back test.

- | | Step | Action |
|-----------|------|--|
| Step 0:19 | 1. | <p>Select SERIAL LOOP BACK on the simulator OUTPUT switch.</p> <p>Check that the centre bar of the display segments step continuously across the display.</p> <p>Disconnect the mains adapter and check that the display shows "ErrErr".</p> |
-

NiCd Battery This procedure checks the battery voltage and the attached circuit.
The procedures require the cabinet to be opened.

- | | Step | Action |
|-----------|------|--|
| Step 0:20 | 1. | <p>Load = 750 mA</p> <p>Ensure that the monitor is <u>not</u> supplied from the mains adapter (supplied from the NiCd battery only).</p> <p>Connect the DVM to the NiCd battery terminals.</p> <p>Check that the voltage is above 7.5 V (fully charged battery).</p> |
| | 2. | <p>+ 5 V</p> <p>Connect DVM+ to TP3 and DVM- to TP4 on the Main PCB.</p> <p>Check that the voltage is 5.000 ± 0.005 V.</p> |
| | 3. | <p>+ 5 V RAM</p> <p>Switch off the monitor.</p> <p>Connect DVM+ to TP 8 and DVM- to TP 4 on the Main PCB.</p> <p>Check that the voltage is above 3.0 V.</p> |
-

Continued on next page

Checkout and Adjustment, *Continued*

Bat Light Bar

The following test/adjustment is performed while the monitor is in normal monitoring mode (Simulator ELECTRODE switch not in pos. TEST.).

The procedures require the cabinet to be opened.

Step	Action
------	--------

- | | |
|----|---|
| 1. | Ensure that the mains adapter and the TCR3/REC recorder cable is <u>not</u> connected to the Monitor. |
| 2. | Connect a variable power supply to the monitor's internal battery leads <u>instead</u> of the NiCd battery.
Adjust the power supply to 9 volts and switch on the monitor. |
| 3. | Reduce slowly the power supply voltage until the BAT light bar begins to flash.
Check using a DVM that the power supply voltage is 7.20 ± 0.1 V.
If outside, adjust the potentiometer R51 on the Main PCB.
<u>Hint:</u> If the "BAT low" activation voltage is above 7.30 V, turn the potentiometer counter-clockwise.
If it is below 7.10 V, turn the potentiometer clockwise. |
| 4. | Repeat steps 2 and 3. |
| 5. | Remove the power supply and the DVM and reconnect the NiCd battery. |
| 6. | Reprogram the Setup and AUX programs. |
| 7. | Check the mmHg/kPa and in-vivo cal. settings in the service program, step 0:04. |

Monitor Performance Check

Introduction

The System Performance Check procedure is intended for the monitor and its accessories without the need of any measuring instruments or tools. The check is recommended before installation.

If the analog or serial data outputs are used, the instruments normally connected to these terminals are used for the check. These can be a TCR3/REC or an analog recorder.

The Performance Check procedure makes use of the built-in test program which is called by switching on the TCM3 while the ALARM OFF and SET keys are activated simultaneously.

The ALARM OFF key is used to step through the test program. The direction of the stepping can be reversed by the SET key.

The actual "Step-number" is displayed in the AUX display (except steps 1 and 5).

Ensure that the internal battery is fully charged before starting the performance check.

Setup Program

The following steps are carried out to check the Setup program.

Step	Action
1.	Supply TCM3 from the mains by the Mains Adapter.
2.	Connect an electrode to the Monitor and switch on. All display segments, light-bars and the audio alarm are activated for a short period. The CAL light-bar flashes, calling for a calibration.
3.	Press the SET key to call the Setup program and check it in accordance with the Operator's Manual.

AUX Program

The following is carried out to check the AUX program.

Step	Action
1.	Press the ▲ and ▼ keys simultaneously for 3 seconds to call the AUX program. Check it according to the Operator's Manual.

Calibration

The following steps are carried out to check the calibration.

Step	Action
1.	Press the CAL key and perform a calibration according to Operator's Manual.
2.	Switch off the Monitor.

Continued on next page

Monitor Performance Check, *Continued*

Analog Outputs The following steps are carried out to check the analog outputs.

Step	Action
1.	Connect an analog recorder to the 15 pole "D" connector by the Radiometer analog cable 617-851 and switch on the Monitor.
2.	Re-calibrate and check that the pO_2 and pCO_2 analog outputs are in accordance with the data displayed on the monitor.
3.	Switch off the Monitor.

Serial Data Output The following steps are carried out to check the serial data outputs.

Step	Action
1.	Connect a TCR3 or REC recorder the 15-pole "D" connector and switch on the Monitor.
2.	Re-calibrate and check that the output data is in accordance with the monitor display and the SETUP and AUX programs.
3.	Switch off the monitor.

Self-Test The following steps are carried out to check that the internal self-test runs correctly.

Step	Action
1.	Switch on the TCM3 while the ALARM OFF and SET keys are activated simultaneously. All display segments, light-bars and the audio alarm will be activated for a short period. The AUX display is showing the software version number (the first 10 seconds flashing).
2.	Press the ALARM OFF key to advance the test program.

Continued on next page

Monitor Performance Check, *Continued*

Keys and Display Segments

Step 0:02

The following steps are carried out to check the keys and display segments.

Step	Action
------	--------

- | | |
|----|--|
| 1. | Press the SET key. The AUX display and its light-bars will be activated. |
| 2. | Press the ▲ key. The pO_2 display and its light-bars will be activated. |
| 3. | Press the CAL key. The pCO_2 display and its light-bars will be activated. |
| 4. | Press the ▼ key. The audio alarm steps through all levels. |

Dip Switch

Step 0:04

These step is carried out to check that the DIP switches are read correctly.

The procedure is valid for TCM3 monitors below RUN 22 only.

The DIP switch code is shown in the pCO_2 display as a hexadecimal number.

Step	Action
------	--------

- | | |
|----|---|
| 1. | Check that the code is in accordance with one of the following: |
| | mmHg, in-vivo cal.: 3F |
| | mmHg, not in-vivo cal.: 7F |
| | kPa, in-vivo cal.: BF |
| | kPa, not in-vivo cal.: FF |

Please observe that in-vivo cal. is not approved by the FDA in the USA:

In-vivo cal. /mmHg - kPa

Step 0:04

TCM3 Monitors from RUN 22 onwards do not include the DIP switch. Instead, the functions are selected from the front panel. These steps are carried out to check that the selection is possible.

Step	Action
------	--------

- | | |
|----|--|
| 1. | Switch between mmHg and kPa by the ▲ or ▼ key, (the decimal points are lit in both the pO_2 and the pCO_2 displays when kPa is selected) |
| 2. | Switch between in-vivo cal and not in-vivo cal by the Cal key. The AUX display indicates in-vivo cal. |
| 3. | Ensure that the monitor settings are correct before continuing with the next step. |

Continued on next page

Monitor Performance Check, *Continued*

Power Supply	Disconnect the mains adapter and check that the display light level decreases.
---------------------	--

Step 0:20

Electrode Performance Check

Introduction

This procedure is intended for the following electrodes: E5237 ($p\text{CO}_2$), E5247 ($p\text{O}_2$), E5277 ($p\text{O}_2/p\text{CO}_2$) and E5280 ($p\text{O}_2/p\text{CO}_2$ solid state).

The electrode performance check is to be performed in case of a malfunction for troubleshooting, and upon completion of a service repair for verifying the electrode performance. The check results should be documented in the table at the end of this paragraph. The results should be filed for future reference.

The following instruments and accessories are required (and assumed to be OK):

TCM3 monitor

TCC3 or A7450 calibration unit

CAL1 gas (green) (5% CO_2 , 20.9% O_2), part no. 962-107

CAL2 gas (blue) (10% CO_2 , 0% O_2), part no. 962-098

Accessory kit, i.e.

For E5237: D824, part no. 904-309

For E5247: D826, part no. 904-308

For E5277 and E5280: D280, part no. 904-892

Before the performance check it is recommended to remembrane the electrode unless you want to check an error diagnosis. If so, it is recommended to test the electrode twice. First with the original membrane, secondly, with a new membrane.

If the old membrane has been mounted on the electrode for a long time and the electrolyte has dried out, the electrode should be cleaned with distilled water and rubbed thoroughly with the cleaning paper. *Never use emery paper or similar.*

Heating, Signal Range and Stability

These checks are performed during a normal calibration procedure.

Refer to the standard procedure as described in the Operator's Manual. Preset the temperature to 45 °C. Use the Green calibration gas.

Heating

The preset temperature (± 0.05 °C) must be reached within three minutes. If not, ERROR 1 will be flashing in the AUX display and an acoustic beep will be heard. This error may be provoked if the ambient temperature is below the specified minimum temperature of 15 °C.

If the electrode temperature sensing system is defective, i.e. the temperature sensors or their connections, ERROR 10 or 11 (displayed in the $p\text{O}_2/p\text{CO}_2$ displays + continuous acoustic alarm for five seconds) may be called. However, these errors are normally caused by a defective or mis-aligned monitor.

Continued on next page

Electrode Performance Check, *Continued*

Signal Range

The electrode signal must be within the specified range, see below, within one minute after the electrode has reached the preset temperature. If not, ERROR 2 will be flashing in the AUX display and an acoustic beep will be heard. For the combined pO_2/pCO_2 electrodes ERROR 2 will only be displayed if both parameters are outside range. If only one is outside, its display will show "- - -". The signal range check is finished when pO_2 and pCO_2 values are displayed.

Monitor pO_2 range is: $-4.0 * B * 0.209$ to $-0.5 * B * 0.209$
(-636 to -79.5 mV, at $B = 760$ mmHg).

Monitor pCO_2 range is: $49 + V_T$ to $200 + V_T$
where $V_T = 0.0793 * T * \ln(pCO_{2cal} / 38)$, and
 T is the absolute temperature (=318 during the test)

The electrode voltages may be viewed using the service program (step 0:10 for pO_2 and step 0:11 for pCO_2).

Signal Stability

After heating and range check the stability is checked. The average drift must be less or equal to 1% per minute within 15 minutes after the SIGNAL RANGE CHECK. If the drift is greater, ERROR 3 will be flashing in the AUX display and an acoustic beep will be heard. For the combined pO_2/pCO_2 electrodes ERROR 3 will only be displayed if the stability check fails for both parameters. If only one fails, its display will show "- - -". The SIGNAL STABILITY CHECK is finished when the green READY LED is activated and an acoustic double-beep is heard.

pCO_2 Response Check

This is a check of the electrode's ability to detect rapid changes in the CO_2 concentration. Remove the electrode from the holder after calibration (READY) and check that ERROR 4 is not displayed in the AUX display. This "crack" check is normally only relevant for E5237 and E5277 with glass pCO_2 electrodes.

pCO_2 sensitivity check

This check is carried out using the service program.

Insert the electrode in the holder and select test mode step 11. Press the $\blacktriangle$ key to start electrode heating. Supply green cal1 gas to the electrode holder. Wait 10 minutes for the signal to stabilize and read the signal value in the pO_2/pCO_2 displays (displayed as 0.x xx.x where x xx.x is in mV).

Change the gas supply to the blue cal2 gas (10% CO_2) and read the electrode signal after 10 minutes. Check that the signal difference between the "blue gas signal" and the "green gas signal" is minimum 17.0 mV corresponding to a minimum sensitivity of 90%.

The sensitivity is calculated as follows (V_{gas2} and V_{gas1} are in mV):

$$S(\%) = \frac{(V_{gas2} - V_{gas1}) * 100}{27.243 * (\ln CO2\%_{gas2} - \ln CO2\%_{gas1})} = \frac{V_{gas2} - V_{gas1}}{0.1888}$$

Continued on next page

Electrode Performance Check, *Continued*

pO₂ Zero Point and Sensitivity

These checks are carried out using the service program.

Insert the electrode in the holder and select test mode step 10. Press the ▲ key to start electrode heating. Supply green cal1 gas (20.9% O₂) to the electrode holder. Wait 10 minutes for the signal to stabilize and read the signal (which is displayed as 0.x xx.x where x xx.x is in mV).

Change the gas supply to the blue cal2 gas (0% O₂) and read the electrode signal after 10 minutes.

Zero point: Check that the relative zero point, calculated as the relationship between the electrode signal for the blue gas and the green gas, is less than 0.04. The relative zero point is calculated as follows (*B* is the actual barometric pressure):

$$\text{Zero point}(\text{rel.}) = \frac{V_{\text{gas2}} * B}{V_{\text{gas1}} * 760}$$

Sensitivity: Check that *V_{gas1}* is between:

$$mV(\text{min}) = \frac{79.5 * B}{760} \quad \text{and} \quad mV(\text{max}) = \frac{636 * B}{760}$$

corresponding to a sensitivity between 0.5 mV/mmHg and 4.0 mV/mmHg¹⁾.

Please note that a too high sensitivity may be caused by silver deposits on the platinum cathode. The sensitivity may be reduced by remembraning and rubbing the electrode surface carefully with the cleaning paper. **Never use emery paper or similar!**

The sensitivity is calculated as follows:

$$S(mV / mmHg) = \frac{V_{\text{gas1}}}{O_2 \text{ pressure}_{\text{gas1}}} = \frac{V_{\text{gas1}}}{B * 0.209}$$

- 1) Normally, the pO₂ sensitivity is expressed in pA/mmHg, but the system converts the current to an equivalent voltage; 10 pA corresponds to 1 mV.

Continued on next page

Electrode Performance Check, *Continued*

TCM3 Electrode Performance Check Results Document the check results in the table below and file a copy for future reference. Accept criteria are shown in brackets for each parameter.

Step	Result
Heating	Error displayed: (None)
Signal Range	Error displayed: (None)
Signal Stability	Error displayed: (None)
pCO₂ Response	Error displayed: (None)
pCO₂ sensitivity	Vgas1 = mV Vgas2 = mV Vgas2 - Vgas1 = mV (>17 mV)
pO₂ Zero Point	Barometric pressure = mmHg Vgas1 = mV Vgas2 = mV Zero point(rel) = mV (<0.04)
pO₂ Sensitivity	Vgas1 (min) = mV Vgas1 (max) = mV Vgas1 within limits? (Yes)
Overall Evaluation	(All above criteria fulfilled)
Engineer	
Date (YYYY.MM.DD)	

Error Codes

Introduction

The error codes are divided into two categories. "Soft Errors" are displayed in the aux. display (flashing) and an acoustic beep is heard. "Hard Errors" are displayed in the pO_2/pCO_2 displays accompanied by a continuous acoustic alarm for five seconds.

Soft Errors are numbered from 0 to 5 and are caused by incorrect operation or defective accessories, e.g. electrodes or electrode membranes.

Hard Errors are numbered from 10 to 16 and are normally related to electronic disturbances or a defective Monitor. However, Error 10 and 11 may be caused by a defective electrode (temperature sensors).

Soft Errors

The table lists the error codes as well as the possible causes and Service actions.

Error Code	Cause	Service Action
0	RAM has lost its content due to, e.g.; the internal battery is completely exhausted or disconnected.	Check setting in service program, step 4 (mmHg/kPa and in-vivo cal.). Reprogram the Setup and AUX programs.
1	The electrode has not reached the pre-set temp. within 3 minutes. Defective electrode.	Re-calibrate. If error persists, replace the electrode. Replace the electrode.
2	Electrode signal range not acceptable. Incorrect preset calibration. The membrane has not been changed regularly. Unsuccessful membranizing. Poor supply of calibration gas. Defective electrode.	Recalibrate. Remembrane and then recalibrate. Check the value and recalibrate. Remembrane and then recalibrate. Remembrane. Check the gas source and connection. Replace the electrode.
3	Electrode stability not acceptable. Membrane has not been changed regularly. Unsuccessful membranizing. Poor supply of calibration gas. Defective electrode.	Recalibrate. Remembrane and then recalibrate. Remembrane and recalibrate. Remembrane. Check the gas source and connection. Replace the electrode.

Continued on next page

Error Codes, *Continued*

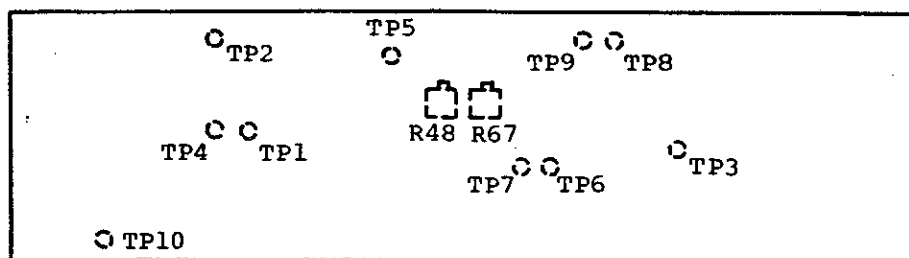
Soft Errors (continued)

Error Code	Cause	Service Action
4	No detection of change in $p\text{CO}_2$ signal after READY.	Recalibrate. Replace the electrode and then recalibrate
5	The electrode power dissipation has exceeded 600 mW for more than 2 minutes due to too low ambient temperature. Defective electrode.	Raise the ambient temperature and recalibrate. Replace the electrode.

Hard Errors

The table lists the error codes as well as the possible causes and Service actions.

Error Code	Cause	Service Action
10	Temperature error. Either higher than 45.6 °C or lower than 5 °C.	Change the electrode. If the electrode is OK, checkout and adjust the monitor.
11	Temperature difference between the two thermistors (E5277 and E5280 only) exceeds 0.6 °C.	Same as for error 10.
12	Parity error.	Reset the microcomputer by switching off and on the monitor. if the error persists, replace the Main PCB.
13	Microcomputer hardware error.	Checkout and adjust the monitor. If the error persists, replace the Main PCB.
14	EPROM checksum error.	Same as for error 12.
15	Software error.	Same as for error 12.
16	Software deadlock.	Same as for error 12.
99	Software version 5.6 only: Same as for error 11.	Same as for error 10.

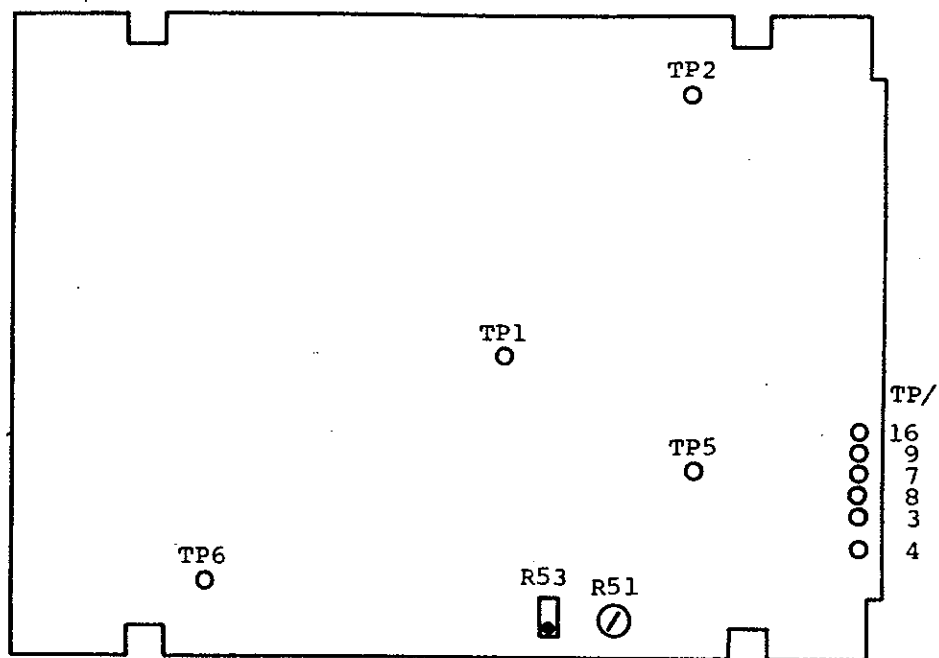


SCALE 1:2

TEST POINTS AND
ADJUSTMENT COMPONENTS

SOLDER SIDE VIEW

POWER SUPPLY PC-BOARD
ASSEMBLY 901-832

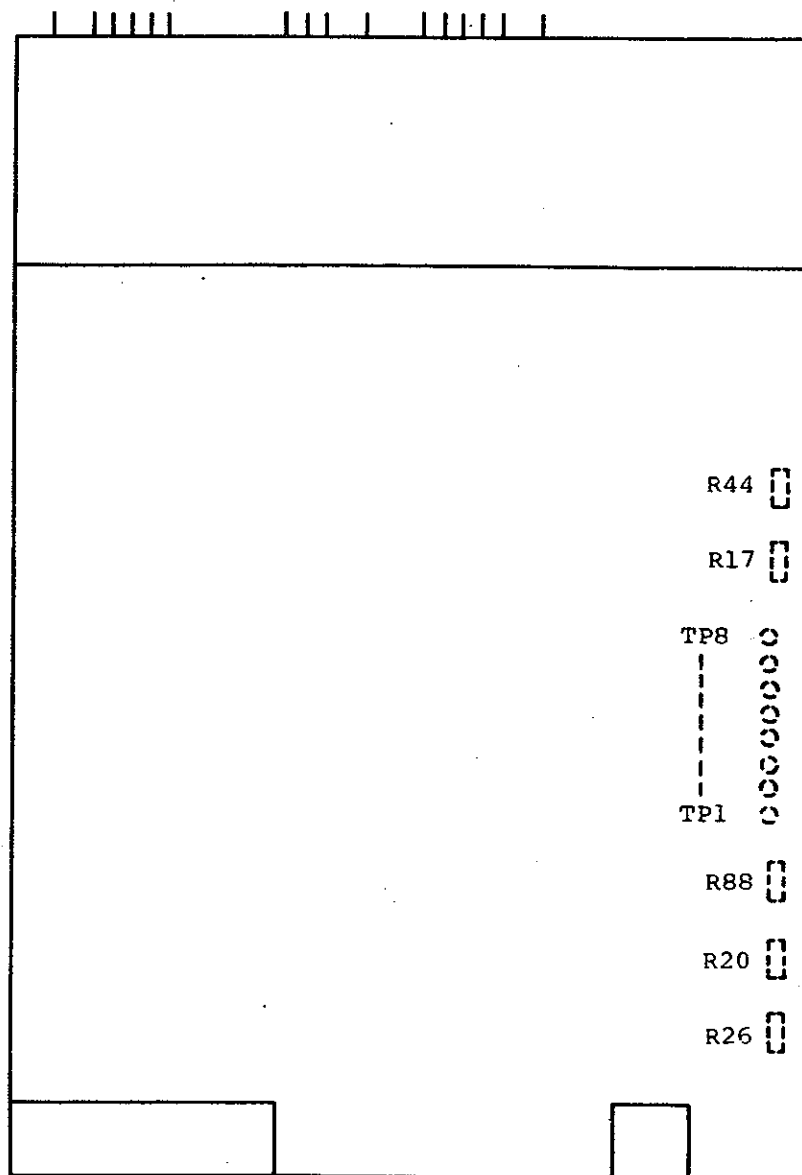


SCALE 1:2

TEST POINTS AND
ADJUSTMENT COMPONENTS

COMPONENT SIDE VIEW

MAIN PC-BOARD
ASSEMBLY 901-834



SCALE 1:1

TEST POINTS AND
ADJUSTMENT COMPONENTS

SOLDER SIDE VIEW

ANALOG PC-BOARD
ASSEMBLY 901-835

Dismantling and Replacements

Overview

Introduction	This section details the procedures for dismantling the monitors and replacing parts.
Contents	This section contains the following topics.
	Procedures 2-36

Procedures

Introduction To dismantle and replace the various parts of the TCM3, the following tools are necessary:

Screwdriver 6 x 1 mm

Pozidrive screwdriver, # 0

Pozidrive screwdriver, # 1

Wrench for the 6 mm hexagonal stand-offs

The numbers in brackets refer to the exploded view in Section 4.

Cabinet (9) Disconnect all accessories, and switch off the Monitor.

Step	Action
1.	Turn the monitor upside down and remove the 4 bottom screws (11) through the Short form holes, and then carefully lift-off the bottom cover.
2.	When replacing it, ensure that the front and rear grooves latch into the Front Plate (1)/Display PCB (5) and the Rear Plate (19)/Power Supply PCB (15), respectively. See that the 8 felt pads are in place. Be sure that no leads become clamped, and that the top and bottom covers fit together completely before tightening the screws.

NiCd Battery (30)

Step	Action
1.	Disconnect the two battery leads.
2.	Unscrew the four screws securing the battery to the bottom cover and remove the unit.
3.	When the battery is disconnected from the monitor, the RAM memory loses its data information. When the monitor is switched on again after the replacement, Error 0 will be displayed. Reprogram the Setup and AUX programs.

Continued on next page

Procedures, Continued

Analog PCB (24)

Step	Action
1.	Unscrew the three screws securing the PCB to the stand-offs (25).
2.	Disconnect the two power supply amphenol connectors, lift the on/off switch and the electrode plug from their grooves and turn the Analog PCB.
3.	Remove the aluminium screen (26) from the five Main PCB stand-offs (27) and disconnect the flat-cable connector from the Main PCB.
4.	Disconnect the on/off switch (16) and the 3-pole display cable. Note the orientation of the electrode plug in the slot of the top cover and the on/off switch cable on the side near the Main PCB.

Main PCB (28)

Step	Action
1.	Disconnect the flat-cable connector next to the Display PCB.
2.	Unscrew the four stand-offs and the two screws securing the PCB and screen to the cabinet.
3.	Separate the PCB from the screen by removing the five remaining screws.

Power Supply PCB and Rear Plate (15) and (19)

Step	Action
1.	Disconnect the power supply cable (17) and lift the PCB and the rear plate out of their grooves and then separate them.
2.	When reassembling, ensure that the cables are not clamped and that the connector slot (17) is directed towards the rear plate edge.

Continued on next page

Procedures, Continued

Display PCB and Front Plate (5) and (1)

Step	Action
1.	Remove the electrode holder (2) by unscrewing the large front screw (32).
2.	Lift the PCB and the front plate out of their grooves.

If replacing the keys, remember to assemble the key-parts before mounting them into their respective holes on the front plate.

If the silicone protection plate for the four small keys is replaced, remember to fasten it to the front plate by the self-adhesive tape.

Adjustment of the Electrode Holder Microswitch (6)

Step	Action
1.	Note in which direction the switch must be adjusted.
2.	Loosen the micro-switch by loosening the two small screws (35). Adjust the micro-switch position and then refasten it.
3.	Check the adjustment by inserting an electrode in the electrode holder.
4.	Repeat steps 1 through 3 until the adjustment is correct

Spare Parts List

Overview

Introduction	This section lists the spare parts available for servicing the TCM3 monitor. The spare parts list specifies to which extend the monitor may be serviced as only the spare parts listed may be replaced.						
Contents	This section contains the following topics.						
Contents	<table><tr><td>Introduction</td><td>2-40</td></tr><tr><td>TCM3 Below RUN 22</td><td>2-41</td></tr><tr><td>TCM3 RUN 22 Onwards</td><td>2-43</td></tr></table>	Introduction	2-40	TCM3 Below RUN 22	2-41	TCM3 RUN 22 Onwards	2-43
Introduction	2-40						
TCM3 Below RUN 22	2-41						
TCM3 RUN 22 Onwards	2-43						

Introduction

Introduction

All spare parts available for the TCM3 are listed in this section which also includes an exploded view to ease the identification of the parts.

When ordering spare parts include the part number and the description of the part.

Trade-in Parts

The Modules marked with an * must be returned to RADIOMETER for replacement. This is to ensure the highest possible degree of patient and functional safety.

They will be replaced in accordance with our Trade-in arrangement for Modules, with the exception of modules that have been damaged during attempted repairs.

Two Lists

The Spare Parts List has been divided into two. One list includes the spare parts for TCM3 of RUN 1-21, and the other includes the spare parts for TCM3 of RUN 22 onwards.

TCM3 Below RUN 22

Parts Available The numbers in the left column refer to the exploded view at the end of this Section.

Ref. No.	Part No.	Quantity	Description
1	978-458	1	Front Plate for TCM3, English, mmHg
	978-499	1	Front Plate for TCM3, English, kPa
	978-500	1	Front Plate for TCM3, German, mmHg
	978-501	1	Front Plate for TCM3, German, kPa
	978-502	1	Front Plate for TCM3, French, mmHg
	978-503	1	Front Plate for TCM3, French, kPa
2	940-542	1	Electrode Holder for TCM3, complete
3	927-018	1	Set of keys for TCM3, complete
4	923-093	1	Spacer for Electrode Holder, TCM3
5	901-645	1	* Display PCB for TCM3, complete
6	540-047	1	Micro-switch for TCM3, complete w. cable
7	826-239	1	Bracket for micro-switch, TCM3
8	884-864	1	Retaining Plate f. microswitch, TCM3
9	927-017	1	Cover for TCM3, complete
10	977-125	1	Short Form Instruction f. TCM3, English
	983-580	1	Short Form Instruction f. TCM3, German
	983-581	1	Short Form Instruction f. TCM3, French
11	001-440	4	Screw, M4 x 40
12	042-410	4	Washer
13	927-019	2	Bottom Rail for TCM3, complete
14	837-133	4	Rubber foot, self adhesive
15	901-644	1	* Power Supply PCB f. TCM3, complete
16	551-175	1	On/off switch f. TCM3, compl. w. cable
17	636-014	1	Connector with cable for TCM3
18	923-117	1	Bracket for cassette hinge, TCM3
19	885-687	1	Rear Plate for TCM3
20	856-219	1	Socket for Spring Lock, TCM3
21	885-716	1	Spacing Plate for Spring Lock, TCM3
22	864-691	1	Bushing for Rear Plate, TCM3
23	041-002	1	Isolation Washer

Continued on next page

TCM3 Below RUN 22, *Continued*

Parts Available (continued)	Ref. No.	Part No.	Quantity	Description
	24	901-652	1	* Analog PCB for TCM3, complete
	25	039-793	3	Stand-off for Analog PCB, TCM3
	26	885-685	1	Screen for TCM3
	27	039-792	5	Stand-off for Main PCB, TCM3
	28	901-643	1	* Main PCB for TCM3, complete
	29	885-684	1	Screen for Main PCB, TCM3
	30	431-010	1	NiCd Battery Unit for TCM3, incl. fuse, and compatibility "kit" for monitors of Runs 1 through 21
		431-012	6	NiCd Cell
	31	450-031	1	Fuse for NiCd Battery Unit
	32	002-914	1	Screw for Electrode Holder, M3 x 9.4
	33	835-398	1	O-ring
	34	066-412	1	Bushing
	35	008-110	2	Screw, M2 x 10
	36	042-207	2	Washer
	37	008-306	12	Screw, M3 x 6
	38	046-901	13	Spring Washer
	39	031-302	4	Nut, M3
	40	009-308	4	Screw, M3 x 8, countersunk
	41	010-308	6	Hex Head Screw, M3 x 10 (2.5 mm tool)
	42	046-405	6	Washer
	43	008-308	9	Screw, M3 x 8
	44	042-306	2	Washer
	45	042-307	2	Washer

TCM3 RUN 22 Onwards

Parts Available The numbers in the left column refer to the exploded view at the end of this Section. For parts which can only be used on specific monitors this is indicated in the description. For parts which may be used in both TCM3 and TCM30 the description does not specify this.

Ref. No.	Part No.	Quantity	Description
1	978-541	1	Front Plate for TCM3, English, mmHg
	978-544	1	Front Plate for TCM3, English, kPa
	978-542	1	Front Plate for TCM3, German, mmHg
	978-629	1	Front Plate for TCM3, German, kPa
	978-543	1	Front Plate for TCM3, French, mmHg
	978-788	1	Front Plate for TCM30
2	940-542	1	Electrode Holder, complete
3	927-018	1	Set of keys for TCM3, complete
4	923-278	1	Spacer for Electrode Holder
5	901-836	1	* Display PCB for TCM3, complete
	902-470	1	* Display PCB for TCM30, complete
6	540-047	1	Micro-switch, complete w. cable
7	826-239	1	Bracket for micro-switch
8	884-864	1	Retaining Plate f. micro-switch
9	927-057	1	Cabinet for TCM3, complete
10	983-647	1	Short Form Instruction f. TCM3, English
	983-648	1	Short Form Instruction f. TCM3, German
	983-649	1	Short Form Instruction f. TCM3, French
	983-650	1	Short Form Instruction f. TCM3, Italian
	983-651	1	Short Form Instruction f. TCM3, Spanish
	983-652	1	Short Form Instruction f. TCM3, Swedish
	983-653	1	Short Form Instruction f. TCM3, Dutch
	983-654	1	Short Form Instruction f. TCM3, Danish
11	001-440	4	Screw, M4 x 40
12	042-410	4	Washer
13	927-031	2	Bottom Rail, complete
14	837-133	4	Rubber foot, self adhesive
15	901-832	1	* Power Supply PCB, complete incl. Fuse

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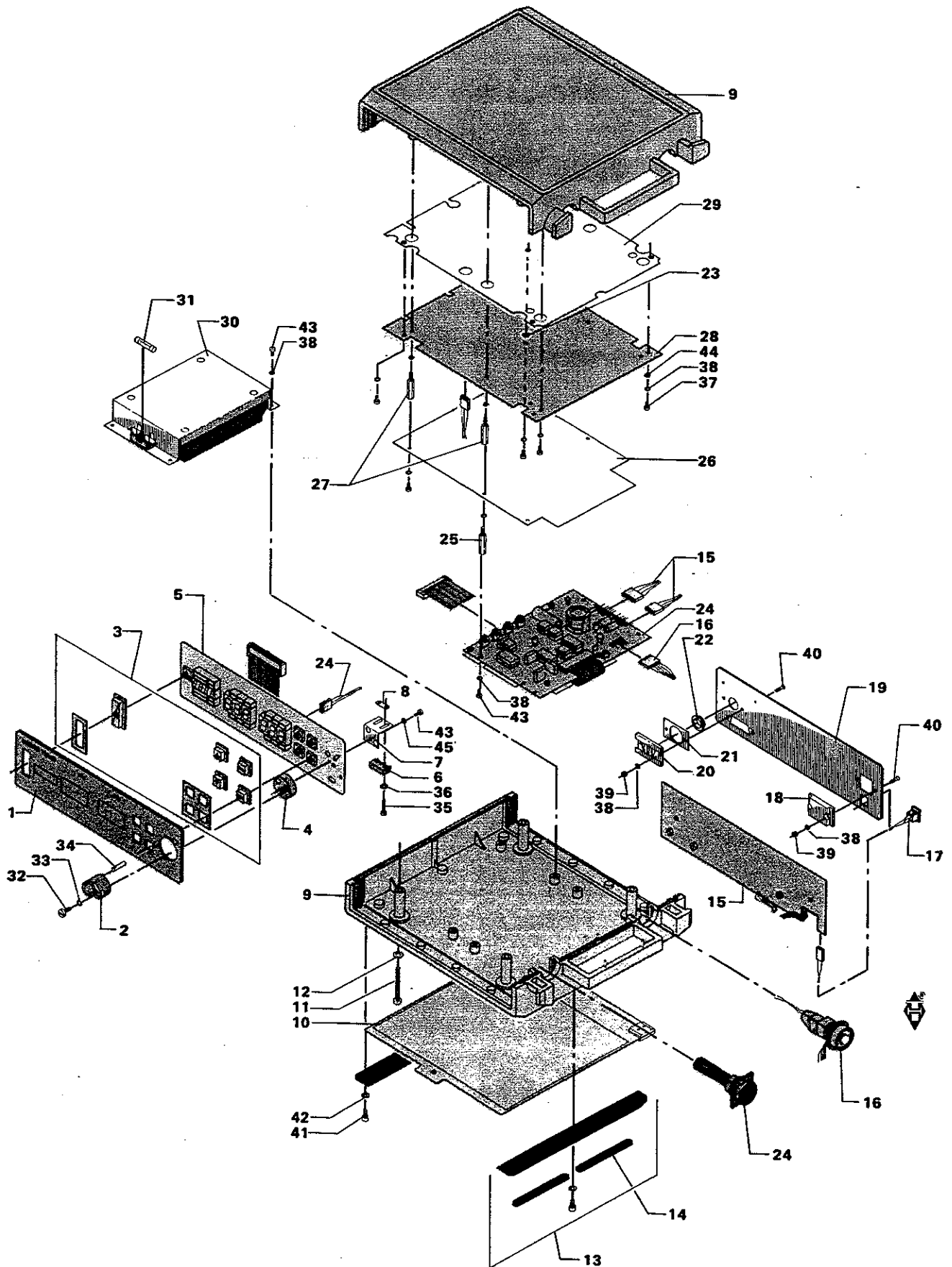
TCM3 RUN 22 Onwards, *Continued*

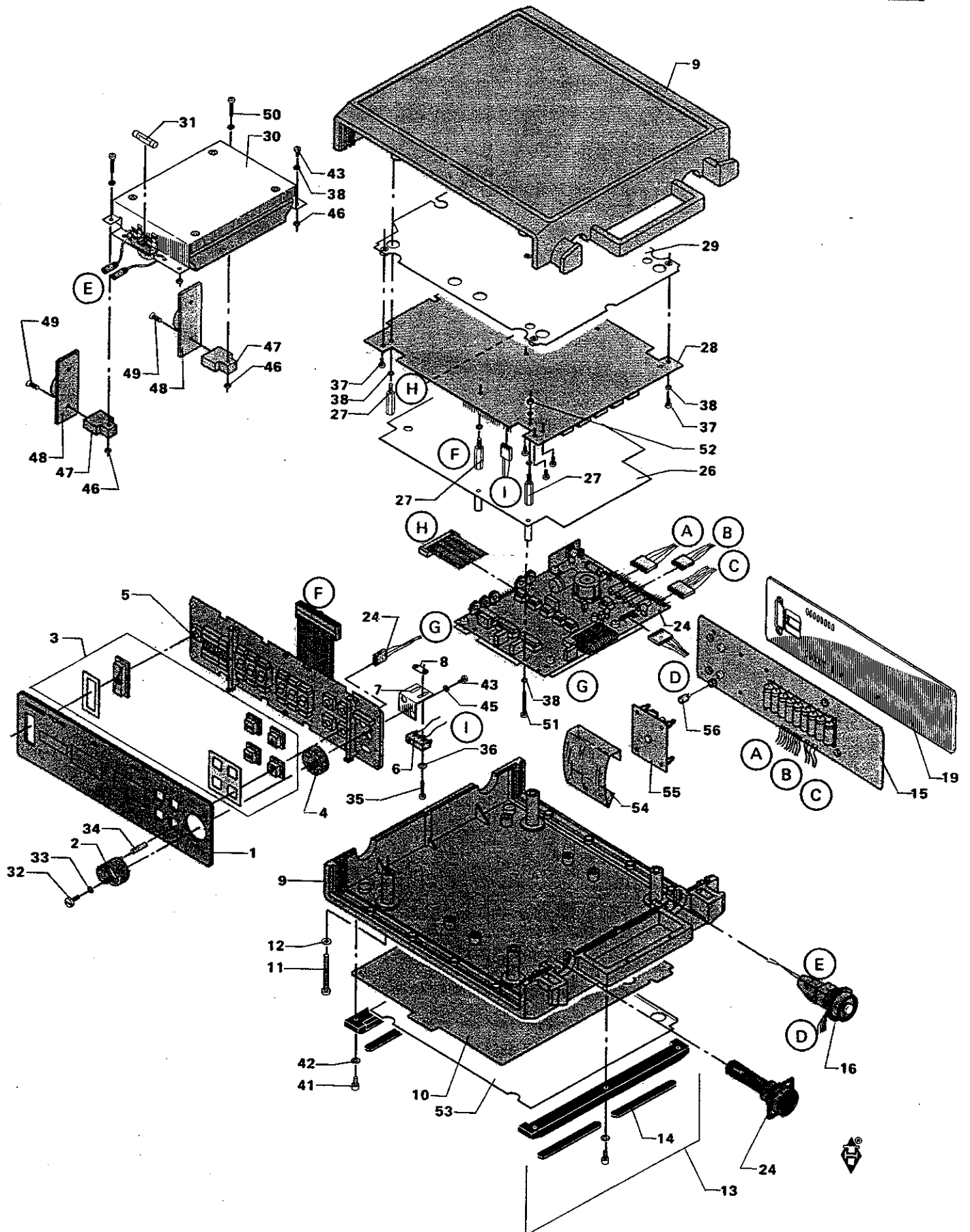
Parts Available (continued)	Ref. No.	Part No.	Quantity	Description
	16	551-175	1	On/off switch, complete w. cable
	19	978-523	1	Rear Plate (below RUN 146)
		978-524	1	Rear Plate (RUN 146 onwards)
	24	901-835	1	* Analog PCB for TCM3, complete with screen (Runs 22 through 145)
		902-428	1	* Analog PCB for TCM3 (RUN 146 onwards) and TCM30, complete with screen
	26	885-816	1	Screen
	27	039-792	5	Stand-off for Main PCB
	28	901-834	1	* Main PCB for TCM3, complete
		902-491	1	* Main PCB for TCM30, complete
	29	885-817	1	Screen for Main PCB
	30	431-010	1	NiCd Battery Unit, incl. fuse, and compatibility "kit" for TCM3 of Runs 1 through 21
		431-012	6	NiCd Cell
	31	450-031	1	Fuse for NiCd Battery Unit
	32	002-914	1	Screw for Electrode Holder, M3 x 9.4
	33	835-398	1	O-ring
	34	066-412	1	Bushing
	35	008-110	2	Screw, M2 x 10
	36	042-207	2	Washer
	37	008-306	12	Screw, M3 x 6
	38	046-901	13	Spring Washer
	41	010-308	6	Hex Head Screw, M3 x 10 (2.5 mm tool)
	42	046-405	6	Washer
	43	008-308	9	Screw, M3 x 8
	46	043-106	4	Washer
	47	886-239	2	Bracket for Accessory Hinge
	48	923-163	2	Accessory Hinge
	49	009-310	2	Screw, M3 x 10, countersunk
	50	008-316	2	Screw, M3 x 16
	51	008-325	3	Screw, M3 x 25

Continued on next page

TCM3 RUN 22 Onwards, *Continued*

Parts Available (continued)	Ref. No.	Part No.	Quantity	Description
	52	031-302	1	Nut, M3
	53	885-783	1	Bottom Plate
	54	993-063	1	Insulating Foil
	55	901-831	1	Output PCB, complete with Nylon stand-offs and insulating foil
	56	450-131	1	Fuse for 901-832





Circuit Description

Overview

Introduction

This section gives detailed information as to the build-up and function of the electronics. It provides the background information required for servicing the monitors.

Please note that this section covers both the TCM3 and the TCM30 for which reason some statements/paragraphs concern only one of the monitors.

Block Diagrams

An overview of the electronics is given in the block diagrams as follows:

Monitor	Diagram
TCM3 below RUN 22	3759-A2, revision 0
TCM3 from RUN 22 onwards	3759-A2, revision 1
TCM30	8530-A3

Contents

This section contains the following topics.

Analog PCB.....	2-48
Main PCB.....	2-54
Power Supply PCB.....	2-59
Output PCB	2-64
Display PCB	2-65

Analog PCB

Introduction

The Analog PCB carries out the following functions:

- Analog to digital conversion of the pO_2 , pCO_2 and other electrode signals.
- Control of the electrode heat current and measurement of the electrode power dissipation.
- Charging of the NiCd battery and supply of polarisation voltage and power to the electrode and its pre-amplifiers.
- Constitution of the patient barrier, that is the transformer and the opto-couplers.

Three Versions

Please note that three versions of the Analog PCB exist. The table below gives an overview of the versions and their compatibility.

Part	Used for	Compatibility	Drawing
901-652	TCM3 below R22	None	2369-A1
901-835	TCM3 of R22 through R145	None	2440-A1
902-428	TCM3 of R146 onwards and TCM30	None	8423-A3

Electrode Input/ Output Circuit

The electrode plug functions are transferred to A/D Converter 1 via the input multiplexer QA10 and the voltage follower QA1d. The transfer functions are:

MUX channel	Signal	Transfer Function, $V(TP6)=$
0	pCO_2	$-14.7 \cdot V(pCO_{2in}) - 0.669$
1	pO_2	$V(pO_{2in})$
2	Polarisation Voltage	-680 mV
3	Thermistor 2	$-0.1 \cdot (T - 10)$, Range 37-45 °C
4	Thermistor 1	$-0.5 \cdot (T - 37)$, Range 37-45 °C
5	V_{HEAT}	$-0.3(V_{LOAD} + 20 \cdot I_{LOAD})$
6	I_{HEAT}	$-20 \cdot I_{LOAD}$ (maximum 53 mA)
7	Analog Ground	0

The CPU monitors the electrode power dissipation via R86.

If the electrode temperature exceeds 45.6 °C, the heat current is switched off (QA3a, Q1). Further, the heat voltage will be switched off.

The electrode power supplies, +5 V and -9 V, are protected against short circuits.

Continued on next page

Analog PCB, *Continued*

Electrode Input/ Output Circuit Three electrode terminals are used for coding.
(continued)

Electrode	Pin 10	Pin 16	Pin 18
E5277, E5280 - pO_2/pCO_2	1	0	0
E5247, E5250 - pO_2	1	0	1
E5237 - pCO_2	1	1	0
Electrode Simulator	0	1	1

A/D Conversion The PCB includes two similar A/D converters. A/D1 converts the signals from the input multiplexer. A/D2 is dedicated to the temperature signal from termistor 1.

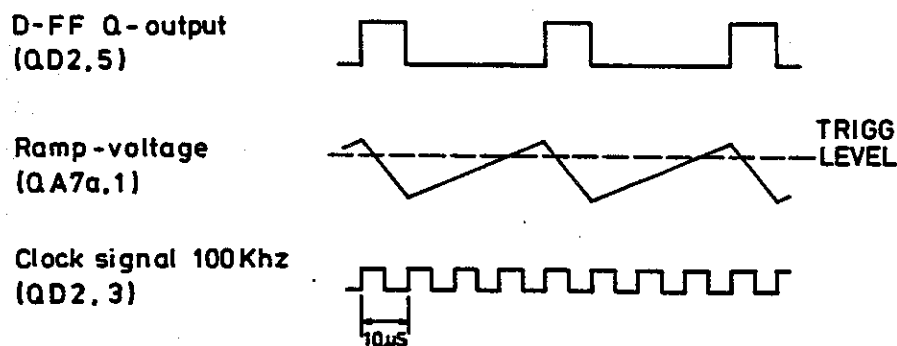
The following description refers to A/D 1.

The converter consists of an integrator and a D-Flip/Flop. The FF is clocked by a symmetrical 100 kHz square wave.

When the FF Q-output is low, the integrator output voltage will increase until the triggering level of the D-FF, is reached. At the next positive clock-pulse edge, the Q-output will go high causing the integrator output and QA7a pin 1 to turn and decrease to below the D-FF triggering level.

At the next clock-pulse the Q-output will go low and a new cycle commences.

The part of the time in which Q is high is called the duty-cycle, d.



Example of A/D converter signals. Duty-cycle = 0.25.

Continued on next page

Analog PCB, Continued

A/D Conversion The nominal duty cycle d (R44 in mid-position) can be expressed as follows:
(continued)

$$d = -V_{in} * \frac{R50}{5 * (0.5 * R44 + R45)} + \left(1 + \frac{R50}{0.5 * R44 + R45}\right) * \frac{R48}{R47 + R48}$$

The frequency of the D-FF Q-output: $f = d * f_{clock}$

The table below lists the duty cycle and frequency as a function of some typical input signals.

MUX channel	Input Signal	TP6	Duty-cycle	Frequency
0 (pCO ₂)	+1 mV	-0.684 V	0.1863	18.63 kHz
	+185 mV	-3.388 V	0.7267	72.67 kHz
1 (pO ₂)	-1 mV	-1 mV	0.0499	4.99 kHz
	-185 mV	-185 mV	0.0867	8.67 kHz
	-4.0 V	-4.0 V	0.8489	84.89 kHz
2 (Pol. volt.)	-680 mV	-680 mV	0.1855	18.55 kHz
3 (Therm. 2)	37 °C	-2.7 V	0.5891	58.91 kHz
	45 °C	-3.5 V	0.7490	74.90 kHz
4 (Therm. 1)	37 °C	0 V	0.0497	4.97 kHz
	45 °C	-4.0 V	0.8489	84.89 kHz
5 (V _{HEAT})	-14.7 V	-4.69 V	0.9878	98.78 kHz
	-11.8 V	-3.53 V	0.7548	75.48 kHz
6 (I _{HEAT})	50 mA	-1.00 V	0.2495	24.95 kHz
	0 mA	0 V	0.0497	4.97 kHz
7 (Ground)	0	0	0.0497	4.97 kHz

The duty cycle d of A/D converter 2 can be expressed:

$$d = -V_{in} * \frac{R60}{5 * R55} + \left(1 + \frac{R60}{R55}\right) * \frac{R58}{R58 + R57}$$

For thermistor 1 = 37 °C, $d = 0.0498$, $f = 4.98$ kHz

For thermistor 1 = 45 °C, $d = 0.8498$, $f = 84.98$ kHz

Continued on next page

Analog PCB, *Continued*

Charging Circuit

The battery contains 6 NiCd cells. Its nominal voltage is 7.2 V (each cell 1.2 V) and the capacity is 2 Ah (25 °C, 360 mA).

The charging current depends upon the TCM3/30 consumption. At low consumption, the charge rate will be high and vice versa.

When the monitor is supplied from the mains, the voltage at TP 7 will be 9.2 V and Q5 is active. The voltage drop across R93 and R94 is constant 0.7 V ($V_{CR19} - V_{BE}$), leaving more to R94 if V_{R93} drops and vice versa.

The table below lists some typical rates of the TCM3/30 consumption, and the corresponding NiCd charging currents.

The figures are indicative only as the consumption depends very much on the actual display showing.

Situation	Current consumption	Charging current
Monitor off, battery fully charged	0	80 mA
Monitor off, battery empty	0	300 mA
Monitor on, waiting for calibration, battery empty	100 mA	300 mA
Monitor on, ready for measuring, electrode temp. 43 °C.	300 mA	30 mA
Monitor on, measuring, electrode temp. 43 °C	300 mA	30 mA

If the monitor is supplied from the battery cassette TCB3 or BAT, the secondary voltage (TP 7) will decrease, Q4 and Q5 cut-off and no charging takes place.

Automatic Secondary Voltage Regulation

This circuit, which applies to the PCBs 901-835 and 902-428 only, consists of the opto-couplers OP3 and OP4, Q6, Q7 and QA8.

A change in the secondary voltage will cause the regulator voltage to change via QA8 and OP4, and counteract the secondary voltage change.

If the monitor is connected to the mains via the mains adapter, the opto-coupler OP3 is activated, Q7 cuts off and the regulation loop will change the secondary voltage from 8.2 to 9.2 V.

Continued on next page

Analog PCB, *Continued*

Switching Circuit for External Battery	OP 5 transfers the monitor on/off information to the Power Supply PCB. The signal is activating/de-activating a FET switching transistor which prevents the external battery from being discharged when the monitor is switched off.
Patient Barrier	The circuits related to the electrodes and thereby the patient, are galvanic isolated from the mains supply, the battery cassette and recorders, computers, etc., connected to the TCM3/30 15-pole D-connector. This galvanic isolation, called the "Patient Barrier", is constituted by the switching transformer T1 and the opto-couplers.
Power Supplies	The +5 VDC supply from the Main PCB is divided into 3 parts, each with separate supply leads to ensure high stability. The +5 V Analog for the operational amplifiers, measure references and electrode supply. The +5 V Digital as pull-up source and for the input opto-coupler. The +5 V Reference for the A/D converter Flip-Flops. The negative supplies are derived from the heat supply voltage, either directly (QA3a) or via the - 9 V regulator, Q2, CR3, R62.
Test Points on 901-652	TP 1 Electrode test option (Not used) TP 2 $p\text{CO}_2$ signal. $V(\text{TP2}) = -14.7 * V(\text{Terminal 13}) - 0.669$ TP 3 Polarisation voltage. - 680 mV. TP 4 Thermistor 1 signal. $V(\text{TP4}) = -0.5 * (T - 37)$. $T = 37 - 45\text{ }^{\circ}\text{C}$ TP 5 Thermistor 2 signal. $V(\text{TP5}) = -0.1 * (T - 10)$. $T = 37 - 45\text{ }^{\circ}\text{C}$ TP 6 See the table on page 1 TP 7 Switching transformer secondary voltage TP 8 Analog ground TP 9 I_{HEAT} signal. $V(\text{TP9}) = -20 * I_{\text{Electrode}}$ TP 10 Serial output data and pulse-width modulated signal for the analog output TP 11 Serial input data TP 12 + 5 V/Reference TP 13 NiCd battery voltage TP 14 Reference Ground TP 15 Not used TP 16 Electrode Heat voltage

Continued on next page

Analog PCB, Continued**Test Points on
901-835**

TP 1	$p\text{CO}_2$ signal. $V(\text{TP2}) = -14.7 * V(\text{Terminal 13}) - 0.669$
TP 2	Thermistor 1 signal. $V(\text{TP2}) = -0.5 * (T - 37)$. $T = 37 - 45\text{ }^\circ\text{C}$
TP 3	Thermistor 2 signal. $V(\text{TP3}) = -0.1 * (T - 10)$. $T = 37 - 45\text{ }^\circ\text{C}$
TP 4	Reference Ground
TP 5	+ 5 V/Reference
TP 6	See the table on page 1
TP 7	Switching transformer secondary voltage
TP 8	- 9 V

Main PCB

Introduction

The Main PCB is CPU controlled and includes:

- The front panel control for the display, the keys, the audio transducer and the electrode holder micro-switch.
- The serial interface for the digital input-output/analog output, and the counting system for the pO_2/pCO_2 and heat monitoring channels.
- 8 kbyte RAM and 56 kbyte program memory.
- Of particular importance is the electrode heating control function. Apart from the software control, a hardware watchdog will switch off the heat if a software error occurs.

The circuitry is shown on the drawings 2370-A1 and 3690-A2.

Three Versions

Please note that three versions of the Main PCB exist. The table below gives an overview of the versions and their compatibility.

Part	Used for	Compatibility
901-643	TCM3 below R22	None
901-834	TCM3 from R22 onwards	Hardware identical to 902-491
902-491	TCM30	Hardware identical to 901-834

Micro-computer

The microcomputer consists of the CPU, QD1, the EPROMs QD9 and QD6, the RAM QD8 and the address latch QD13.

A parity generator/controller (QD7, QD12 and QD26) uses the least significant bit only. Where a parity error is detected, an NMI (interrupt) will be generated.

The addressing takes place via the address bus A8-A15 and the multiplexed address/data bus AD0-AD7 and the address latch QD13.

The RESET-IN is activated at power-on and resets all peripherals with the RESET-OUT signal.

If the NiCd battery voltage falls to below 6.5 volts, QA5b pin 7 will go high, cutting-off Q12. This will activate Q2, discharge C31 and reset the CPU. The Power Save (PS) input is activated in order to let the CPU finish its current instruction cycle before being reset.

The CPU oscillator is driven by a 1.6 MHz crystal, setting the CLK to 0.8 MHz.

QD18 and QD17 are binary counters, producing the following internal timing signals: 100 kHz clock for the Analog PCB, 163.84 and 655.36 ms reference signals for the two A/D converters, 0.64 ms for the Bus Request (BREQ) signal and 10.24 ms for the CPU interrupt RSTA (used for the "watchdog").

Continued on next page

Main PCB, *Continued*

Input-Output

The microcomputer communicates externally with the help of two NSC810 (combined I/O, RAM, Timers) QD2 and QD3 and one UART QD20. The Input-output ports are organised as follows:

Part		Function
QD2	PA0 - PA7	All inputs (5 front panel keys + 3 unused)
QD2	PB0 - PB7	All inputs
QD2	PC0	Electrode type coding input
	PC1	Electrode type coding input
	PC2	Not used
	PC3	163.84 ms clock input
	PC4	A/D converter 2 (Thermistor) input/Timer T1
	PC5	Not used
QD2	T0 input	System clock (CLK)
	T0 output	Pulse width modulated signal for analog recorder output
QD3	PA0	Watch-dog control output
	PA1	Power-down control output (to heat supply)
	PA2	Audio level select output
	PA3 - PA4	Not used
	PA5	Audio level select output
	PA6	Interrupt output (RSTA)
	PA7	Electrode test output (not used)
QD3	PB0	163.84 ms clock input
	PB1	655.36 ms clock input
	PB2	Reset output for parity generator flip-flop
	PB3	Battery low control input (from heat supply)
	PB4	Control input from QA5a (AC charger off)
	PB5	Control input from supervising thermistor
	PB6	Not used
	PB7	Electrode holder micro-switch input

Continued on next page

Main PCB, *Continued*

Input-Output (continued)

Part		Function
QD3	PC0 - PC2	Control output for the Analog PCB input MUX
	PC3	655.36 ms clock input
	PC4	A/D converter 1 input/Timer T1
	PC5	Electrode type coding input
QD3	T0 input	System clock (CLK)
	T0 output	Audio generator

QD20 (UART):

The programmable UART, functions as a transmitter/receiver and baud rate generator.

Parallel data from the CPU is converted to serial form by the transmitter, and appropriate start, stop and parity bits are added to the outgoing serial data.

The incoming data is checked for errors and converted to parallel for transfer to the CPU. When incoming data is detected, an interrupt will be sent to the CPU (RSTB).

For further information please refer to Section 6, Input-Output Signals.

The input/output chips QD2, QD3, and QD20 are selected by the decoder QD4.

Display Control

The display scanning is controlled by the 0.64 ms clock signal from. The display multiplex bus ABCD controls the 4-to-16 line decoder QD15 and each scanning cycle is initiated by a Bus Request (BREQ) signal from QD11 pin 8.

During BREQ the address and data buses are released from the CPU, giving the A0-A3 control to the ABCD bus via the buffer QD14.

The data transfer from QD8 (RAM) to the 7 segments and the display scanning is synchronised by QD16.

Continued on next page

Main PCB, *Continued*

Heat Control

The electrode heating voltage is controlled by the switching regulator, the amplifier QA3c, the switching elements Q6, L1, CR9, C34 and the D/A converter QD23.

The circuit constitutes an inverting power supply system, delivering a negative DC voltage to the Analog PCB.

QA1 contains an oscillator (output at pin 3), a "battery-low" detector output terminal (8), a disable input terminal (6) and a feed-back input terminal (7). The oscillator is timed by C51 to 31 kHz. The switching duty cycle and hence the heating voltage is controlled by the feedback voltage at pin 7 via the amplifier QA3c and the D/A converter QD23.

With an electrode connected to the monitor, the heating voltage ranges from -11 to -15 V, controlled by the temperature thermostating system.

Even without an electrode there will be a negative 10 V supply to the Analog PCB.

The "killer circuit" Q14, R98, Q15 discharges C34 when the monitor is switched off, thus removing the negative voltage from the Analog PCB and the electrode.

The Heat Control System includes a so-called "watchdog" circuit to switch off the heat power in the case of a software failure. QD29 (74HC123), a mono-stable multi-vibrator, requires a trigger pulse every 10.24 ms to prevent its Q-output to switch the heat voltage low (-10 V) and thus switch off the heat.

The watchdog circuit timing signal is controlled by the software which in turn is activated by the interrupt signal RSTA every 10.24 mS (QD11 pin 5).

Audio System

The audio signal from QD3 (T0 out) is attenuated by the analog switch QD28 and R21-R24 according to the control signal from PA2 and PA5 (QD3). The audio signal is amplified by the complementary driver Q4/Q5 to provide the audio transducer with sufficient power.

5V Supply

The power supply is a linear series regulator consisting of Q8, Q9, QA3a and associated components.

In addition to being the supply for the Main PCB circuits, the regulator constitutes a stable reference for the Analog PCB monitor circuits.

Q13/R99 limits the regulator max. current to 200 mA.

The regulator is started when the input voltage exceeds 6 volts, thus activating Q12 and supplying Q9 with base current.

The RAM is powered via Q10. When the monitor is switched-off, Q10 will be cut-off and the RAM is supplied via terminal J7/14 directly from the NiCd battery.

Continued on next page

Main PCB, *Continued*

"BAT" Light Bar Control

The display segment "BAT" will be activated if the mains adapter or the battery cassette is removed, informing the user that there is only a limited power available.

This function is controlled by the comparator QA5a, the output of which will go low if the power supply voltage (Ext. Pwr. Sense) drops to below 7.8 volts.

If the NiCd battery unit is discharged to 7 V, the LBR (Low Battery Reference) terminal of QA1 will pass its reference level of 1.3 V, and LBD (Low Battery Detect) will go low and activate the Light Bar Flashing Programme.

R14 between Low Battery output and input, gives the function a certain hysteresis.

Test Points

The PCB includes the following test points: -

Test Point	Signal
TP1	TX serial data
TP2	RX serial data
TP3	+5V
TP4	Ground
TP5	Heat supply voltage
TP6	A short-circuit to ground will produce a permanent BREQ. (For special test purposes only)
TP7	Potentiometer adjustment (factory adjustment only)
TP8	RAM supply voltage

Power Supply PCB

Introduction

The PCB contains a switching regulator power supply system and a communication system for the analog output and the serial data input-output.

The power supply part has the following power inputs: 12 V AC or DC, supplied from J1 terminal 1/3, 9 to 21 VDC supplied from J5 terminal 6/1, or 7 to 21 VDC supplied from J5 terminal 2/1.

Normally, J1 terminal 1/3 is used for the mains adapter, J5 terminal 1/2 for the battery cassette, and J5 terminal 6/1 for the recorder TCR3 and REC (TCM3 only).

The communication part has two selectable alternatives. Either analog outputs or serial data input/output. A strap between two connector pins selects the analog alternative.

Two opto-couplers interface the communication channels to the Main PCB. They are mounted on the Analog PCB and are part of the patient barrier.

The communication part is active only, when power is supplied via J1 terminal 1/3 or J5 terminal 6/1.

Two Versions

Please note that two versions of the Power Supply PCB exist. The table below gives an overview of the versions and their compatibility.

Part	Used for	Compatibility	Drawing
901-644	TCM3 below R22	None	2371-A1
901-832	TCM3 of R22 onwards and TCM30	None	2438-A1

Switching Transformers

The transformer primary winding receives the switching power from Q1 and delivers it to the secondary where it is rectified and filtered.

The 3rd winding (terminals 3-4) has 3 purposes:

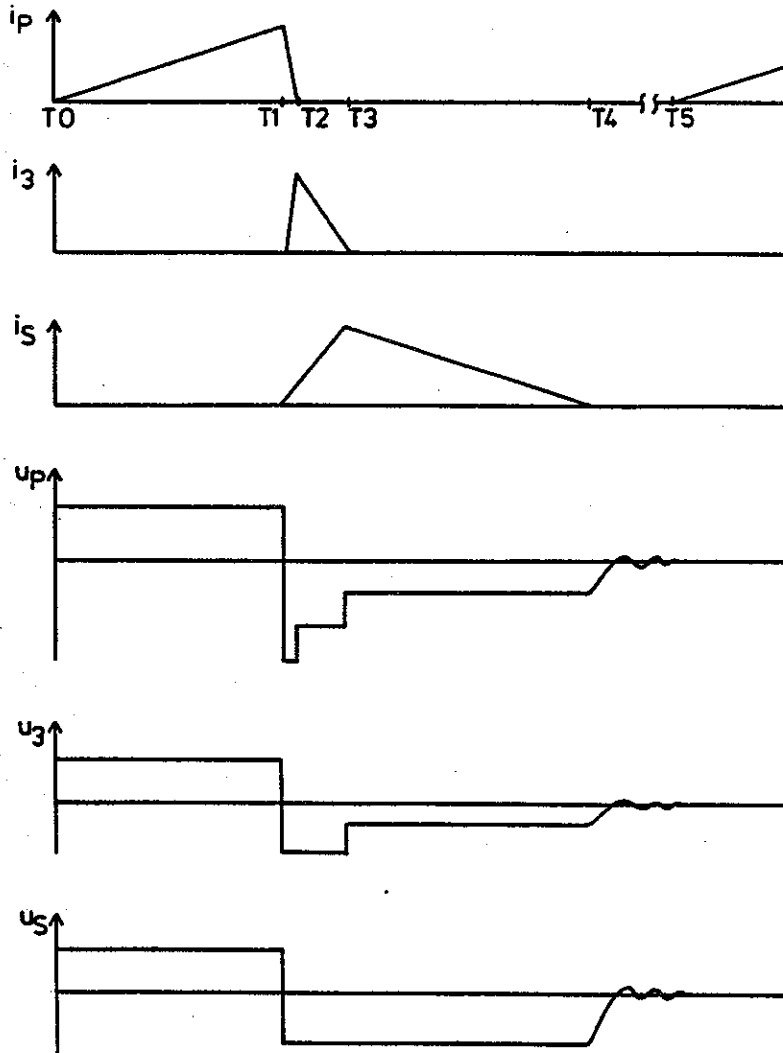
- It increases the efficiency of the system by transferring energy back to the charging capacitors (C11, C1, C10, C69) via CR10 and CR11. This occurs when Q1 switches off the primary current.
- It delivers the input power for the integrated DC regulator QA53 and the serial data output.
- It compensates for the secondary rectifier diode voltage drop via CR9 and the integral regulator QA2.

The transformer pulse signals are shown overleaf.

Continued on next page

Power Supply PCB, *Continued*

Switching Transformers (continued)



Switching transformer pulse signals.

Explanation of the figure:

Current/voltage	Function
i_p, u_p	Current and voltage for the primary winding (3 windings)
i_3, u_3	Current and voltage for the third winding (4 windings)
i_s, u_s	Current and voltage for the secondary winding (6 windings)

Continued on next page

Power Supply PCB, *Continued*

Switching Transformers (continued)

Stage	Description
T0	Q1 is activated and i_p increases linearly. The EMF induced in the secondary is negative at terminal 6. The EMF in winding 3 is negative at terminal 4. C12 is charged through CR13 and R32.
T1	Q1 is cut-off. Back EMF is induced in the primary winding. i_p flows in the loop: Primary terminal 2 - CR12 - CR20 - CR 11 - primary terminal 1. i_p decreases and an EMF is induced in winding 3. i_3 flows in the loop: Terminal 4 - CR10 - CR11 - Charging capacitor - ground - terminal 3. The EMF in the secondary is positive at terminal 6 and the capacitor is charged.
T2	i_p is zero and i_3 decreases.
T3	i_3 is zero and i_s decreases. The emf induced in the primary is positive at terminal 2. Q3 is now cut-off and permits a current to flow in the regulator feed-back loop R1 - Q2 - R6.
T4	i_s is zero and u_p , u_3 and u_s are decreasing. The transformer becomes energyless.
T5	A new cycle commences.

Switching Generator

The generator consists of the saw-tooth oscillator QA1a, the comparator QA1b, the drivers QD1 and the FET Q1.

The comparator acts as a pulse-width modulator where the output signal from QA2b controls the duty cycle of the generator signal.

Integral Regulator on 901-644

This PCB is found in TCM3 below RUN 22.

The regulator is built up around QA2a and QA2b and controls the generator pulse duty cycle and hence the transformer secondary voltage in the following manner:

- Manual adjustment by means of potentiometer R33.
- Automatic regulation by means of the feed back loop: Transformer secondary - transformer primary - R1 - Q2 - CR2.
- Compensation for voltage drop in the secondary rectifier diode via CR9.
- +5 VDC regulator. If the external power is removed, (J1, terminal 1 - 3 or J5, terminal 6 - 1) the integral regulator will reduce the secondary voltage.

Integral Regulator on 901-832

This PCB is found in TCM3 of RUN 22 onwards and in TCM30.

This board does not include the potentiometer R33. Instead, the secondary voltage is automatically regulated via the opto-coupler OP4.

Continued on next page

Power Supply PCB, *Continued*

Current Limiter and Battery Control This function is performed by the mono-stable multi-vibrator QA1c and QA1d. If the instantaneous current in Q1 exceeds a certain value, QA1c will be triggered, causing QA1d, pin 13 and the drive signal for Q1 to go low. To prevent any adverse regulator effects the integral regulator is reset by CR3 and R31.

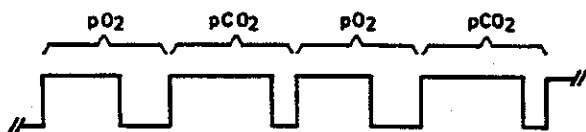
If the battery cassette voltage (+Vbat) drops to below 6 volts, the output of QA1 goes low and the generator signal is disabled.

DC Regulators Three integrated DC regulators QA50 (+5 V), QA52 (+8 V) and QA53 (-5 V), provide the power supply of the communication part.

Serial Data Circuit The serial output signal can be measured at TP 1. It passes via Q51 and Q53. The unloaded output at terminal 11 has an amplitude of 22 V (-14 to +8).
For test purposes, the monitor is fitted with a serial input terminal (14).

Analog Output Circuit on 901-644 This description refers to TCM3 below RUN 22.
The control signal for the analog outputs is a pulse-width modulated square-wave using the same input terminal (TP1) as the serial data TX signal.
Terminals 12 and 13 are short-circuited and the Flip-Flop QD51 is released (pin 6 low). The pO_2 and pCO_2 pulses alternate, and the FF "directs" the pO_2 pulses to QD50 pin 1 and the pCO_2 pulses to pin 13. The FF output is monitored by the microcomputer via Q52.

The signals are demodulated in two active low pass filters.



Example of pulse width modulated signal for the analog outputs. TP 1.

Analog Output Circuit on 901-832 This description refers to TCM3 of RUN 22 onwards and TCM30.
The control signal for the analog outputs is a pulse-width modulated square-wave using the same input terminal (TP1) as the serial data TX signal.
Terminals 15 and 13 are short-circuited and the counter QD51 is released (pin 15 low). The pulses for the 4 analog outputs alternate, and the counter "directs" the pulses to the filter in question.

The counter output is monitored by the microcomputer via Q54 and Q52.

The signals are demodulated in 4 active low pass filters.

Continued on next page

Power Supply PCB, *Continued*

Test Points

The test points available depends on the type of PCB installed as follows:

Test Point	901-644	901-832
TP1	Output signal	Output signal
TP2	N/A	Ground
TP3	N/A	-14 V
TP4	N/A	-5 V
TP5	N/A	+5 V
TP6	N/A	V _{BRIDGE}
TP7	N/A	+5 V _{ref}
TP8	N/A	Ext. battery ground
TP9	N/A	+8 V
TP10	N/A	+V _{ref}

Output PCB

Description

This PCB is found in TCM3 of RUN 22 onwards and in TCM30.

The PCB which is mounted on the Power Supply PCB as a "piggy back", includes a switching FET and various logic circuitry.

The PCB is powered only (V_{BRIDGE} and +5V), if the monitor is mains supplied.

Q1 is on when the gate is low (Q2 on).

When REC is connected to the monitor (TCM3 only), J6/6 is low.

When BAT is connected to the monitor, terminal J6/7 is low.

When the monitor is switched on, J6/8 is low.

If BAT is connected to the monitor, Q6 cuts off, and Q1 goes on via QD1D and Q2. QD1/A pin 3 goes high.

If the monitor is switched on, Q7 cuts off and QD1B pin 6 goes low. Q4 cuts off and Q5 saturates and J6/6 goes low. This makes a FET in BAT, similar to Q1, switch off the charge current to BAT.

If BAT is connected to the monitor, it will be charged only if the monitor is switched off.

If the monitor is switched on and REC is connected (TCM3 only), then QD1/C pin 8 goes low, QD1/D pin 11 goes high, Q2 saturates, Q1 goes on and the recorder is supplied by V_{BRIDGE} .

Display PCB

Introduction

The Display PCB is the interface between the user and the monitor.

It provides visual and audio information and receives user commands via the keyboard and the electrode holder micro-switch.

Three Versions

Please note that three versions of the Display PCB exist. The table below gives an overview of the versions and their compatibility.

Part	Used for	Compatibility	Drawing
901-645	TCM3 below R22	None	2358-A1
901-836	TCM3 of R22 onwards	None	2441-A1
902-470	TCM30	None	8484-A3

Display on 901-645 and 901-836

The PCB includes six 7-segment LEDs for the primary parameters pO_2 and pCO_2 , four 7-segment LEDs for indicating, for example, the electrode temperature, and 18 LED light bars which provide information about the calibration, battery condition, etc.

Data information is received from the Main PCB via connector J2 pins 19 to 26 (7 segments + decimal point).

The displays are orientated in 16 groups and multiplexed via connector J2 pins 1 to 16 and the driver transistors Q17 to Q48.

Display on 902-470

The PCB includes six 7-segment LEDs for the pO_2 parameter, four 7-segment LEDs for indicating, for example, the electrode temperature, and 16 LED light bars which provide information about the calibration, battery condition, unit (mmHg or kPa), etc.

Data information is received from the Main PCB via connector J2 pins 19 to 26 (7 segments + decimal point).

The displays are orientated in 16 groups and multiplexed via connector J2 pins 1 to 16 and the driver transistors Q17 to Q48.

Audio Alarm and Keyboard

The audio transducer receives the audio signal from the Main PCB.

The keyboard includes 5 keys.

Input-Output

Overview

Introduction

This section details the input and output facilities of the TCM3 monitor.

Contents

This section contains the following topics.

Introduction	2-68
Analog Output.....	2-69
Serial Output	2-70
Serial Input	2-78
Monitor State Diagram.....	2-79

Introduction

Introduction

The monitor communicates with external equipment such as printers, analog recorders or personal computers via the 15 pole "D" connector on the rear plate. Two output alternatives are provided. Either analog outputs for pO_2 , pCO_2 , mW/temperature and alarm, (mW/temp. and alarm not in TCM3 below RUN 22) or digital output for serial data such as pO_2 , pCO_2 , heat, temperature, calibration values etc. For test purposes a digital input channel is included. The serial data input-outputs are in accordance with the RS-232-C standard concerning the voltage deviations.

The input-outputs described in this section are active only when the Monitor is powered from the mains or via the rear panel connector terminal 6.

Analog Output

Description

The analog output alternative is selected by short circuiting terminals 15 and 13 (TCM3 of RUN 22 onwards) or terminals 12 and 13 (TCM3 below RUN 22) on the rear panel connector before switching on the monitor.

The analog output is only active in case the monitor is supplied from the mains.

A RADIOMETER 4-channel recording cable is available. It is fitted with a 15-pole female D-connector at one end, and 5 banana plugs at the other. Its length is 2 m and the code number is 617-851. The "D" connector includes a strap between pin 13 and 15, selecting automatically analog output. The analog cable is coded as follows:

Colour / Connector	Signal	Remarks
Green / pin 9	pO_2	5 mV/mmHg (40 mV/kPa) or 1 mV/mmHg (10mV/kPa) selectable in the AUX program.
Yellow / pin 10	pCO_2	10 mV/mmHg (100 mV/kPa) or 5 mV/mmHg (40 mV/kPa) selectable in the AUX program.
Red / pin 8	mW/temp.	Selection between mW and temperature analog output is performed in the AUX program. mW when mW or site timer is selected and temperature when °C is selected. mW: mW is converted to mV. Temp.: 50 mV/°C in the range 30 °C to 50 °C.
Blue / pin 5	Alarm	Acoustic alarm activated: +1000mV. Acoustic alarm not activated: 0mV. Max. source current 1 mA.
Black / pin 15	Common return	

Serial Output

Introduction

The transmission parameters are:

- 2400 Baud
- 7 bits/character
- Odd parity
- 2 stop bits

The output data consists of ASCII characters: Upper case letters, numerals 0 to 9, decimal points, and line terminators <LF>, <CR> and <NUL>.

The data are organised in data-lines divided into 4 categories:

- A Measurement Data and dummy lines
- B Status Messages
- C Events
- D Trend memory dump (RUN 22 onwards only)

Any line is initiated by a 2-letter line-ID followed by a number of 2-letter field-IDs with possible numerals specifying the parameter value.

Category A

These lines are transmitted every 1.966 seconds. When the monitor is in state 1, 2, 3 or 4 (see the state diagram in the paragraph "Serial Input"), and when trend memory data are viewed as well as during X_{OFF} during trend memory dumping, dummy lines (DU) are transmitted. Otherwise measurement data are transmitted.

Measurement Data (DA Package)

Line ID: DA

Field IDs: MO	Measured pO_2	(XXX.Y) mmHg/(XX.YY) kPa
MC	Measured pCO_2	(XXX.Y) mmHg/(XX.YY) kPa
TE	Temperature	(XX.Y) °C
MW	Heating power	(XXX) mW
TI	Site timer	(XX.YY) hours.minutes

Before stability checks during calibrations, the fields MO and MC are omitted. If the monitor is measuring only pO_2 or pCO_2 , the irrelevant field is omitted. The field TI is only included when the site-timer is active, i.e. during state 8, Measure, state 9, In-vivo Measure, and state 11 and 11a, Prepare In-vivo Measure.

Continued on next page

Serial Output, *Continued*

Category A (continued)

Dummy Lines (DU Package)

Line ID: *DU*

Field ID: *DU*

Dummy lines are transmitted instead of measurement data during the Starting, Waiting and Sleep states and when viewing trend memory data and during X_{OFF} when dumping trend memory data.

Category B

This category consists of three types of lines (four in case an in-vivo calibration has been carried out). The lines are transmitted in cycles, one after each line of measured data. Category B lines are not transmitted after dummy lines..

Setup Program (XS Package)

Line ID: *XS*

Field ID: <i>HO</i>	<i>pO₂</i> high limit	(XXX) mmHg/(XX.Y) kPa
<i>LO</i>	<i>pO₂</i> low limit	(XXX) mmHg/(XX.Y) kPa
<i>HC</i>	<i>pCO₂</i> high limit	(XXX) mmHg/(XX.Y) kPa
<i>LC</i>	<i>pCO₂</i> low limit	(XXX) mmHg/(XX.Y) kPa
<i>TI</i>	Site timer Setup	(XX.YY) hours.minutes
<i>TE</i>	Temp. Setup	(XX.Y) °C
<i>CO</i>	<i>pO₂</i> cal. value	(XXX) mmHg/(XX.Y) kPa
<i>CC</i>	<i>pCO₂</i> cal. value	(XXX) mmHg/(XX.Y) kPa

If the monitor is measuring only *pO₂* or *pCO₂*, the irrelevant field is omitted, i.e. if a single parameter electrode is used or if one part of a combi electrode has been rejected during calibration.

Continued on next page

Serial Output, *Continued*

Category B (*continued*)

AUX Program (XF Package)

Line ID: *XF*

Field ID:	DM	site timer display mode (X)	1 = site timer 2 = heating power 3 = temperature
	TR	Trend indication (X)	0 = off, 1 = on
	TC	$p\text{CO}_2$ temp. corr. (X)	0 = off, 1 = on
	MF	Metabolic factor (X) mmHg/(X.Y) kPa	
	AV	Alarm volume (XX)	
	OR	Analog output range, $p\text{O}_2$ (X)	1=0-200 mmHg/0-25 kPa 2=0-800 mmHg/0-100 kPa
	CR	Analog output range, $p\text{CO}_2$ (X)	1=0-100 mmHg/0-10 kPa 2=0-200 mmHg/0-25 kPa
	HT	Heat at site timer expiry (X)	0= off 1= on

If the monitor is measuring only $p\text{O}_2$ or $p\text{CO}_2$, the field CR or OR respectively is omitted. The fields TC and MF are included even if only $p\text{O}_2$ is measured.

Miscellaneous (XX Package)

Line ID: *XX*

Field ID:	PS	TCM3 state (XX). Refer to state diagram in the paragraph "Serial Input"
	AA	Active alarms (XXXXXXX) binary array (0= off, 1= on) active alarms in the following order: high $p\text{O}_2$, low $p\text{O}_2$, high $p\text{CO}_2$, low $p\text{CO}_2$, site timer, temperature.
	UP	Pressure unit (0 or 1) = kPa, 1= mmHg
	VI	In-vivo calibration (0 = disabled, 1= enabled)
	DS	Main board DIP switch position (TCM3 run 1-21 only)
	IE	Electrode current ($p\text{O}_2$) at calibration (XXXX) pA
	VE	Electrode voltage ($p\text{CO}_2$) at calibration (XXX.Y) mV

The fields IE and VE are not included during calibration before start of the stability check. If the monitor is measuring only $p\text{O}_2$ or $p\text{CO}_2$, the field VE or IE, respectively, is omitted.

Continued on next page

Serial Output, *Continued*

Category B (continued)

In-vivo Calibration Parameters (XV Package)

Line ID: *XV*

Field ID: MO	Stored pO_2	(XXX) mmHg/(XX.Y) kPa
MC	Stored pCO_2	(XXX) mmHg/(XX.Y) kPa
SO	Adjusted pO_2	(XXX) mmHg/(XX.Y) kPa
SC	Adjusted pCO_2	(XXX) mmHg/(XX.Y) kPa

This line is only transmitted if an in-vivo calibration has been performed i.e. in state 9 and 10 (also in state 11 if one complete in vivo calibration already has been carried out).

If the monitor is measuring only pO_2 or pCO_2 the irrelevant field is omitted.

Category C

The C-lines are transmitted when an event occurs. Transmission of event lines caused by exit from the Setup or AUX programs or when an in-vivo calibration has been completed will delete one B-line.

Alarm ON/OFF (AN or AF Package)

Transmitted when an alarm goes on or off.

Line ID: *AN* (on) or *AF* (off)

Field ID: One of the following:

HO	High limit pO_2	(XXX) mmHg/(XX.Y) kPa
LO	Low limit pO_2	(XXX) mmHg/(XX.Y) kPa
HC	High limit pCO_2	(XXX) mmHg/(XX.Y) kPa
LC	Low limit pCO_2	(XXX) mmHg/(XX.Y) kPa
ST	Site timer	no value
TE	Temperature	(XX.Y) °C
BA	Flashing BAT light bar	(TCM3 run 1-21 only)

Soft Error (ER Package)

Transmitted when a soft error occurs.

Line ID: *ER*

Field ID: EN Error code (XX), 00 to 05

Altered State (AS Package)

Transmitted when a change of state takes place.

Line ID: *AS*

Field ID: NS new state (XX), 01 to 11

Continued on next page

Serial Output, *Continued*

Category C (*continued*)

Event Mark (EM Package)

Transmitted when the alarm-off key is pressed.

Line ID: *EM*

Field ID: *AO*

Calibration Start (CS Package)

Transmitted when a calibration is started.

Line ID: *CS*

Field ID: *None*

Calibration End (CE Package)

Transmitted when a calibration is completed.

Line ID: *CE*

Field ID: *CO* *pO₂* Cal. value (XXX) mmHg/(XX.Y) kPa

CC *pCO₂* Cal. value (XXX) mmHg/(XX.Y) kPa

IE Electrode current (*pO₂*) at calibration (XXXX) pA

VE Electrode voltage (*pCO₂*) at calibration (XXX.Y) mV

If the monitor is measuring only *pO₂* or *pCO₂* the field *VE* or *IE*, respectively, is omitted.

Exit From Setup Program (SU Package)

Line ID: *SU*

Field ID: Same contents as for Line *XS* (category B)

Exit From AUX Program (FT Package)

Line ID: *FT*

Field ID: Same contents as for Line *XF* (category B)

In-vivo Calibration End (VC Package)

Transmitted when an in-vivo calibration is completed.

Line ID: *VC*

Field ID: Same contents as for Line *XV* (category B)

Continued on next page

Serial Output, *Continued*

Category D

The D-lines are used for Trend memory dump only. During trend memory dumps, no other lines are transmitted (except dummy lines during possible X_{OFF}). If a change of state has taken place during a trend memory dump, the corresponding line will be transmitted after the dump or if it is interrupted.

Trend Memory Data (TD Package)

Transmitted every 0.6 second during the dump when not stopped by X_{OFF} .

No decimal points are used in lines associated to trend dumps.

Line ID: *TD*

Field ID:	OA	Measured pO_2	(XXXX), 15 seconds mean value
	OB	Measured pO_2	(XXXX), 15 seconds mean value
	OC	Measured pO_2	(XXXX), 15 seconds mean value
	OD	Measured pO_2	(XXXX), 15 seconds mean value
	CC	Measured pCO_2	(XXXX), 60 seconds mean value

One line corresponds to 60 seconds of measurement (includes 4 pO_2 values and 1 pCO_2 value). Data are only stored in the states Measure, Prepare In-vivo Measure, and In-vivo Measure. If the monitor was measuring only pO_2 or pCO_2 , the irrelevant field(s) are omitted.

(XXXX) corresponds to 4 times the value in mmHg if mmHg is selected as unit, or 40 times the value in kPa if kPa is selected as unit.

Trend Memory Dump Start, Part 1 (TS Package)

Corresponds to the monitor state at the trend dump starting point. If the monitor was measuring only pO_2 or pCO_2 the field CC or CO, respectively, are omitted, but all alarm limits are included.

Line ID: *TS*

Field ID: Same contents as for line XS (category B) with the limitations written above.

Trend Memory Dump Start, Part 2 (TB Package)

Corresponds to the monitor state at the trend dump starting point. If the monitor was measuring only pO_2 or pCO_2 , the field MC or MO and SO, respectively, are omitted.

Line ID: *TB*

Field ID. Contains the fields TC and MF from the XS line, the fields PS and UP from the XX line, and in case an in-vivo calibration has been carried out, the fields of the XV line (category B)

Continued on next page

Serial Output, *Continued*

Category D (*continued*)

Trend Memory Dump End (TE Package)

Transmitted at the end of trend memory dump.

Line ID: *TE*

Field ID: *DE*

Calibration Error (TR Package)

T(transmitted in case of a calibration error.

Line ID: *TR*

Field ID: EN error code XX:

00 Temperature error

01 Range error, pO_2 , pCO_2

02 Stability error, pO_2 , pCO_2

03 Membrane error

04 Range error, pO_2 only

05 Range error, pCO_2 only

06 Stability error, pO_2 only

07 Stability error, pCO_2 only

08 Heat error

Altered State (TT Package)

Transmitted when a change of state takes place.

Line ID: *TT*

Field NS New state (XX). Refer to TCM3 state diagram in the paragraph "Serial Input"

Calibration Start (TC Package)

Transmitted where a calibration was started.

Line ID: *TC*

Field ID: CO pO_2 cal. value (XXX) mmHg/(XXY) kPa

 CC pCO_2 cal value (XXX) mmHg/(XXY) kPa

If the monitor was measuring only pO_2 or pCO_2 , the irrelevant field is omitted.

Continued on next page

Serial Output, *Continued*

Category D
(continued)

Event Mark (TA Package)

Transmitted where the alarm-off key was pressed.

Line ID: TA

Field ID: AO

Exit From Setup Program (TU Package)

Line ID: TU

Field ID: Same contents as for line XS (category B) with the following modifications: The line includes only fields corresponding to values that were changed or reset (site timer). If no values were changed, the line is omitted.

The line does not include calibration values.

Exit From AUX Program (TF Package)

Line ID: TF

Field ID: Contains the fields TC and MF of the XF line (category B). The line is only transmitted if the temperature correction or the metabolic factor was changed

In-vivo Cal. Completion (TV Package)

Line ID: TV

Field ID: Same contents as XV line (category B)

Serial Input

For Test Purposes only

The serial input is used for test purposes only and requires the electrode plug to be coded as one of the four possibilities below. 0 means that the pin is connected to pin 17 (ground). 1 means that the pin is **not** connected to pin.

Electrode plug	Pin 10	Pin 16	Pin 18
TC Electrode Simulator	0	1	1
pO_2/pCO_2 Electrode, test mode	0	0	0
pO_2 Electrode, test mode	0	0	1
pCO_2 Electrode, test mode	0	1	0

The input data are ASCII characters (numerals 0 to 9). All other characters are ignored. The numerals are interpreted as key activities as set out below:

0	Not used (ignored)
1	CAL
2	SET
3	▲
4	▼
5	▲▼
6	Not used (ignored)
7	Electrode holder microswitch
8	Electrode plug
9	Alarm off key

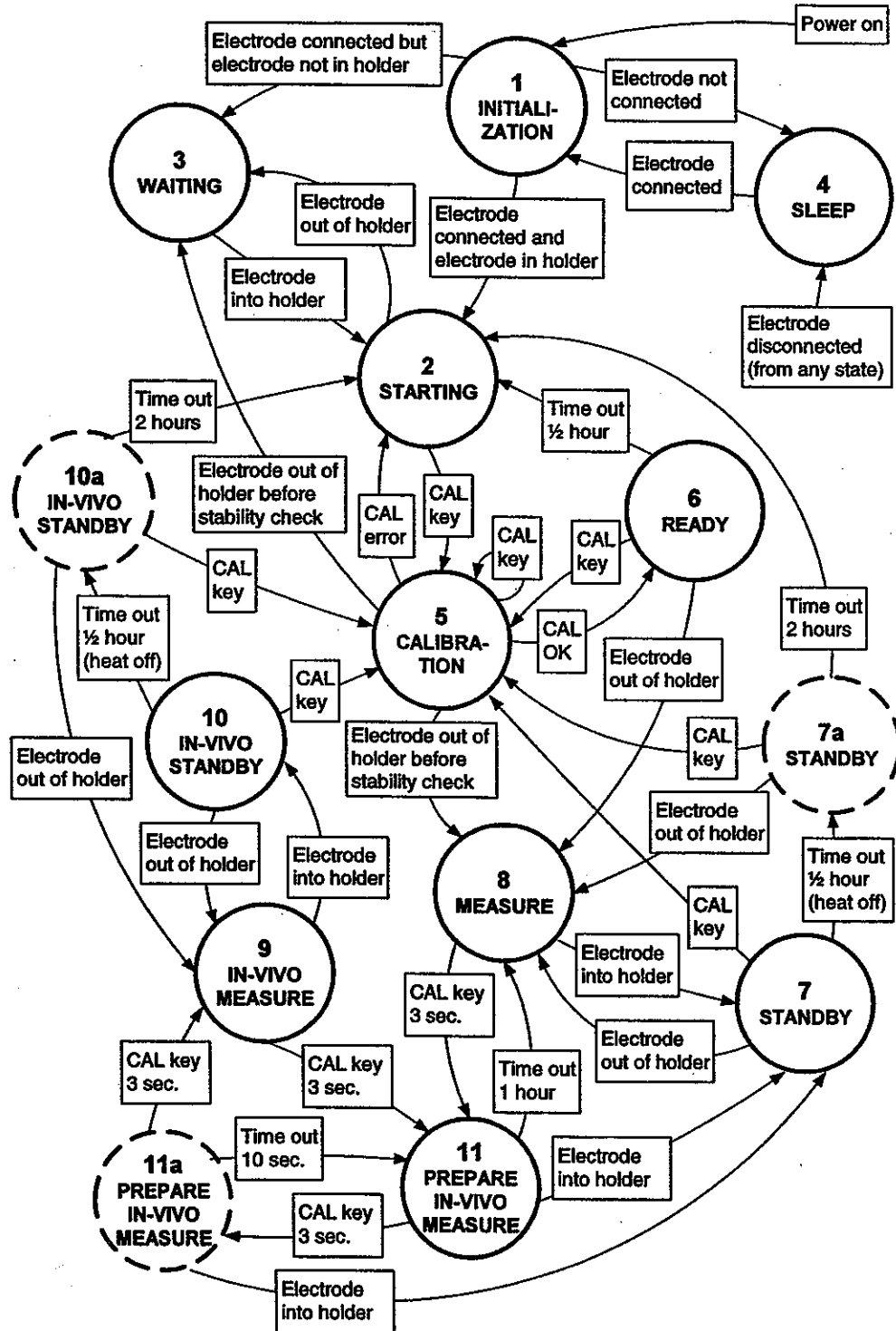
At 7 and 8, the condition change between activated and non-activated, electrode plug in and electrode plug out, respectively.

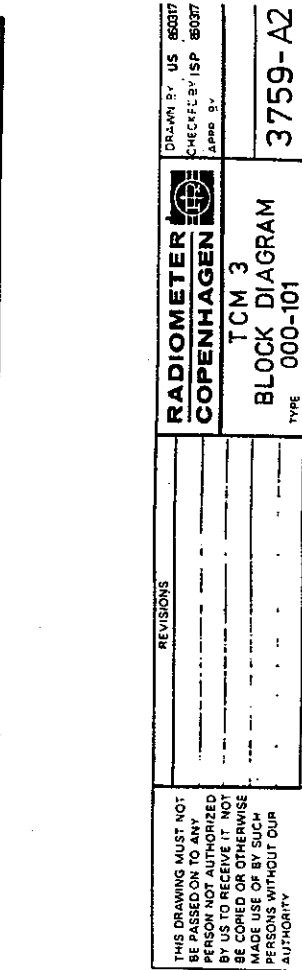
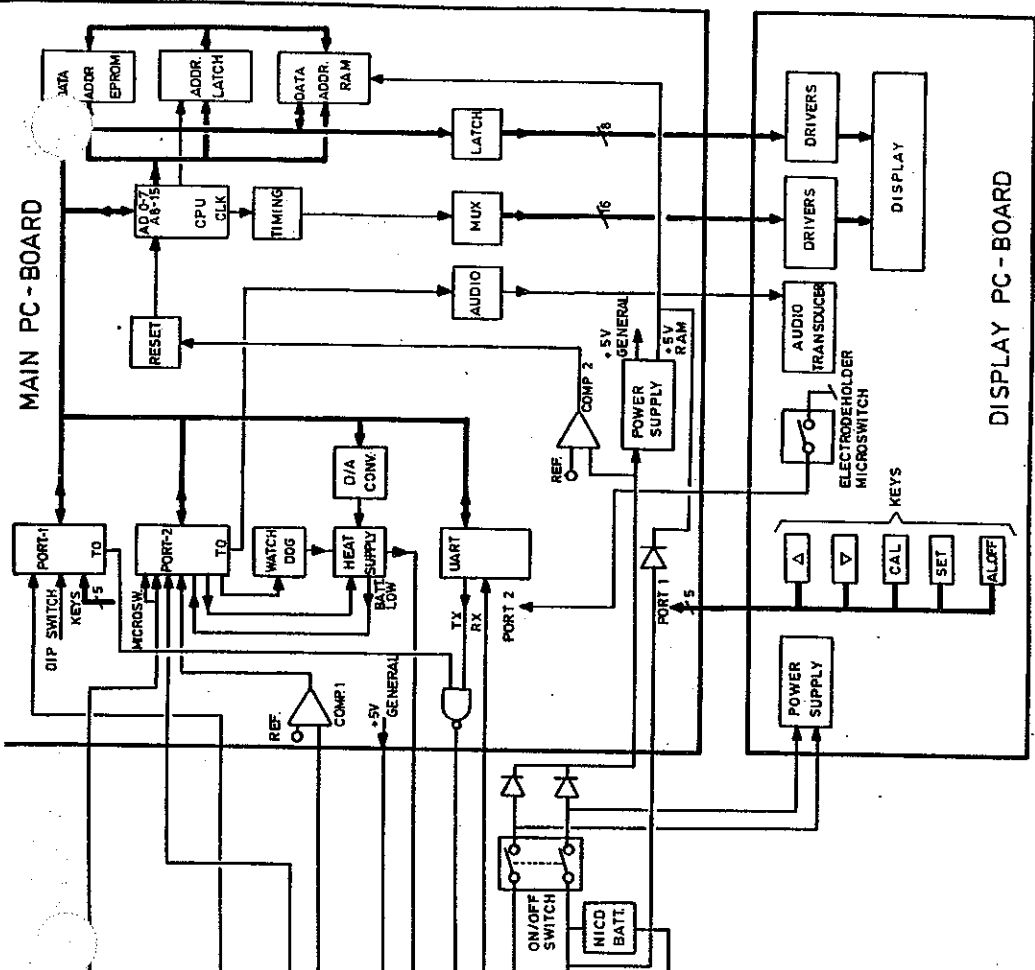
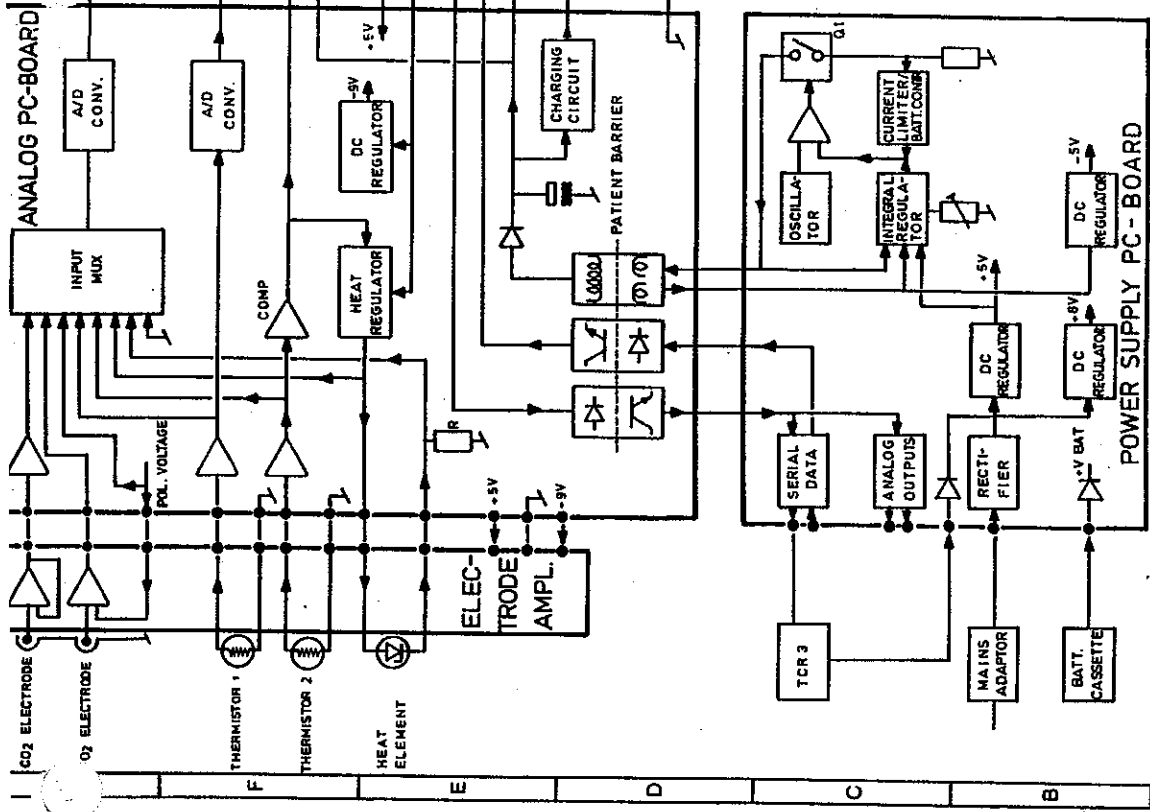
Monitor State Diagram

Introduction

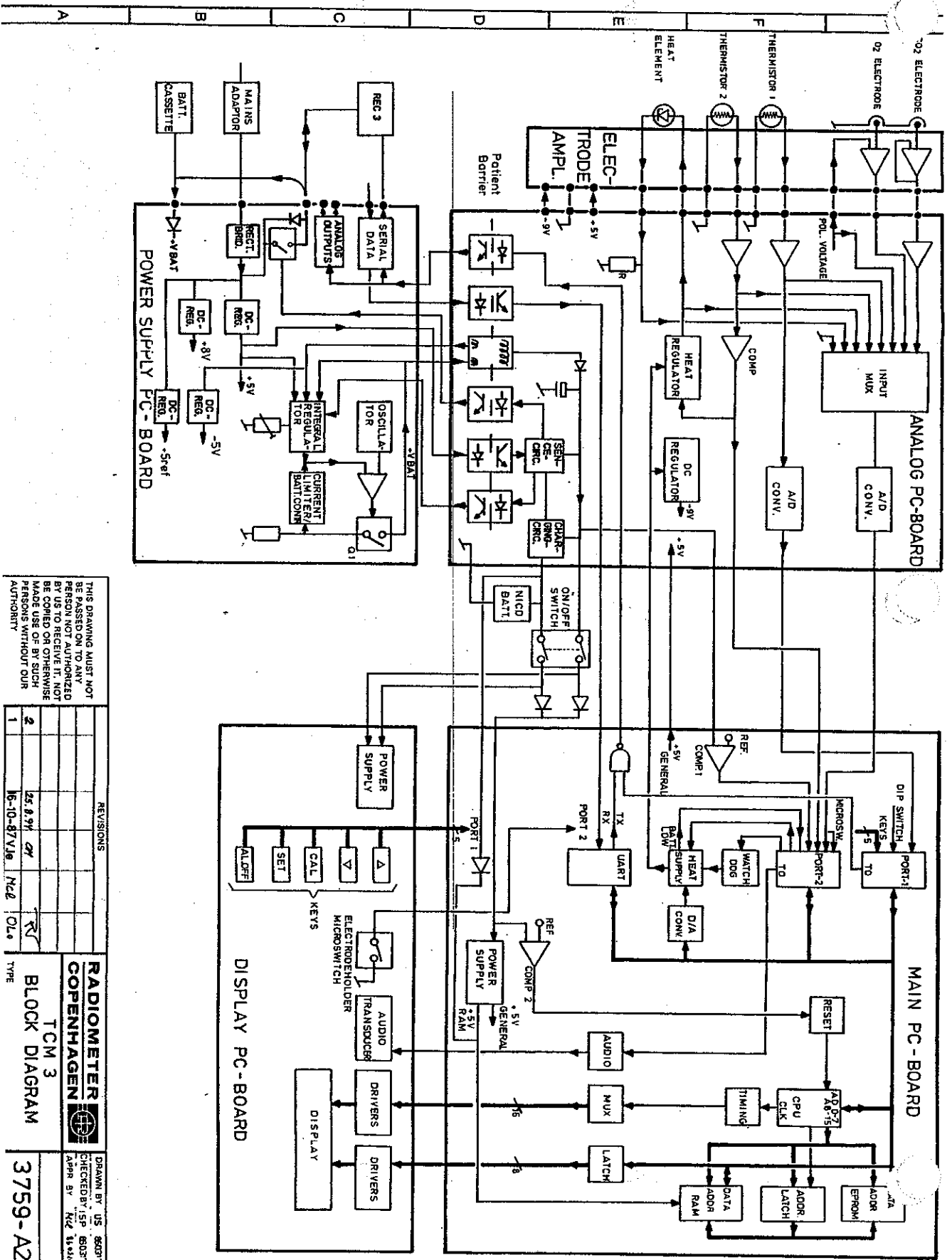
The diagram shows which states the monitor enter into depending on timing and user actions.

State Diagram





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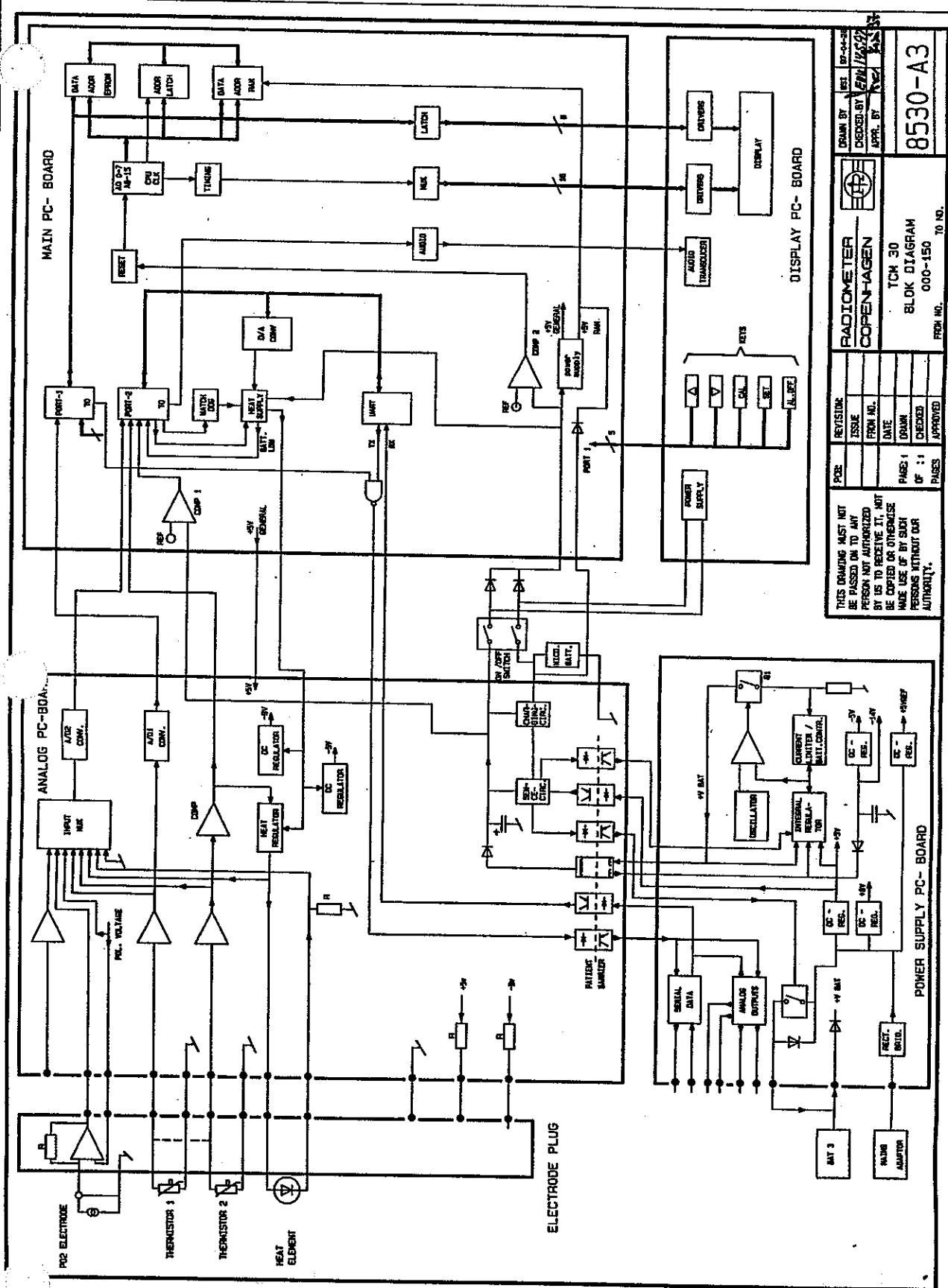


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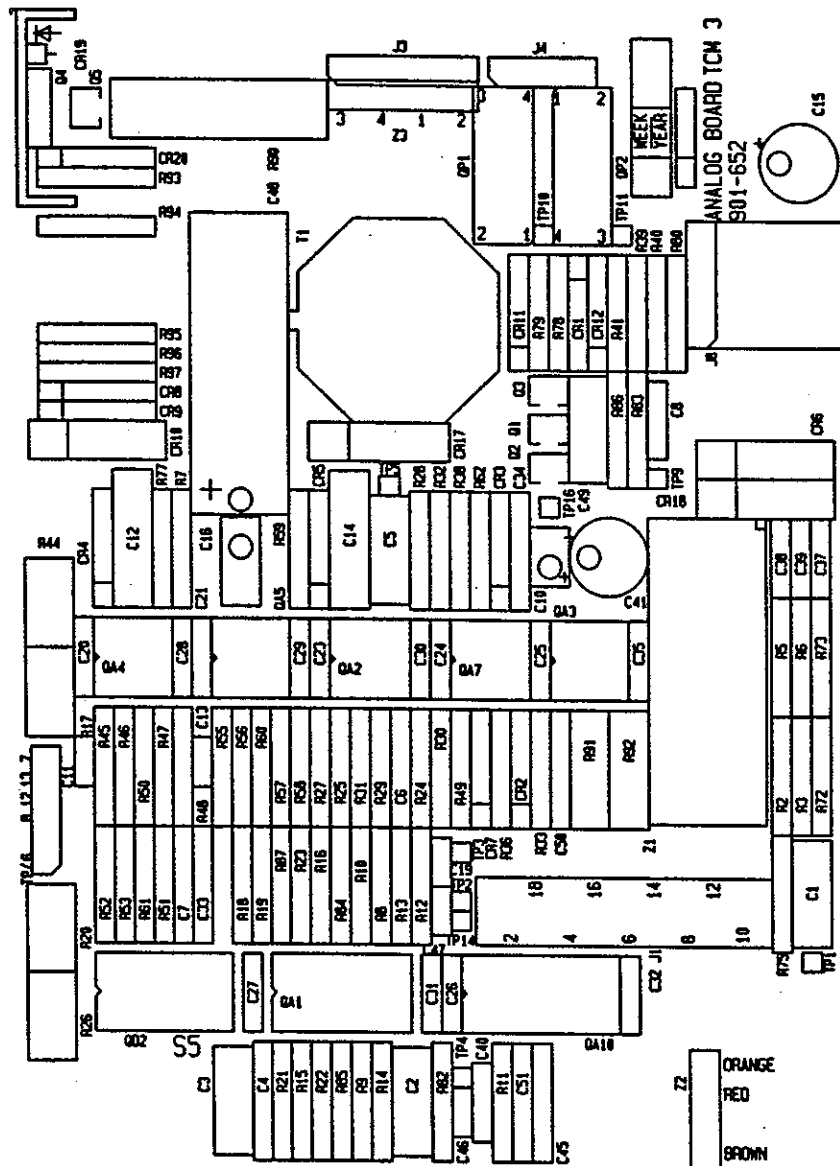
REVISIONS	
1	16-10-87 V19 NCL CL
2	25.8.94 CM

RADIOMETER COPENHAGEN
TCM 3
BLOCK DIAGRAM
3759-A2

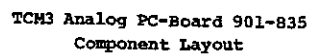
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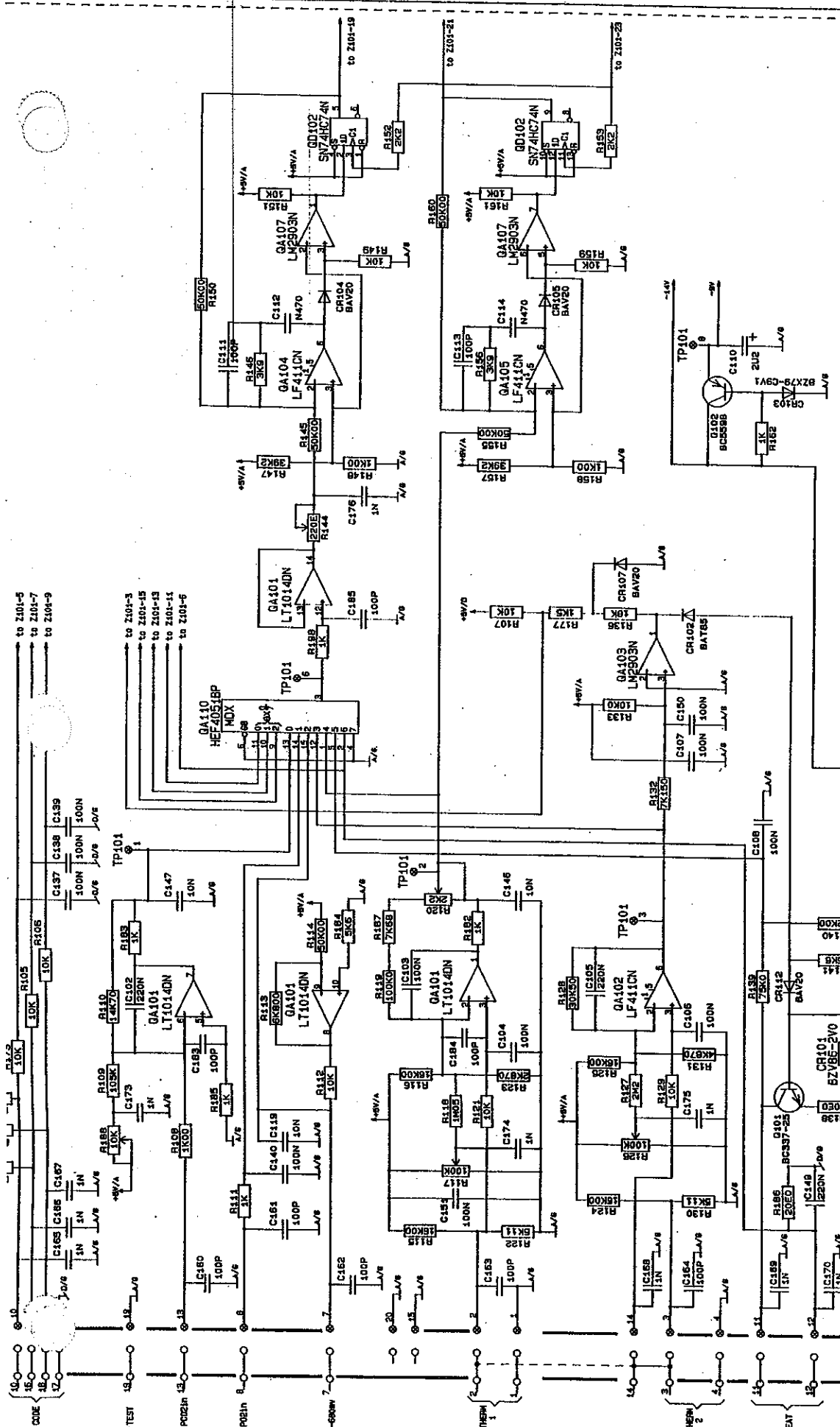
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TCM3 Analog PC-Board 901-652
Component layout



TCM3 Analog PC-Board 901-835
Component Layout



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COPENHAGEN**

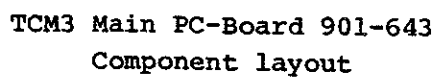
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TMC3 902-428

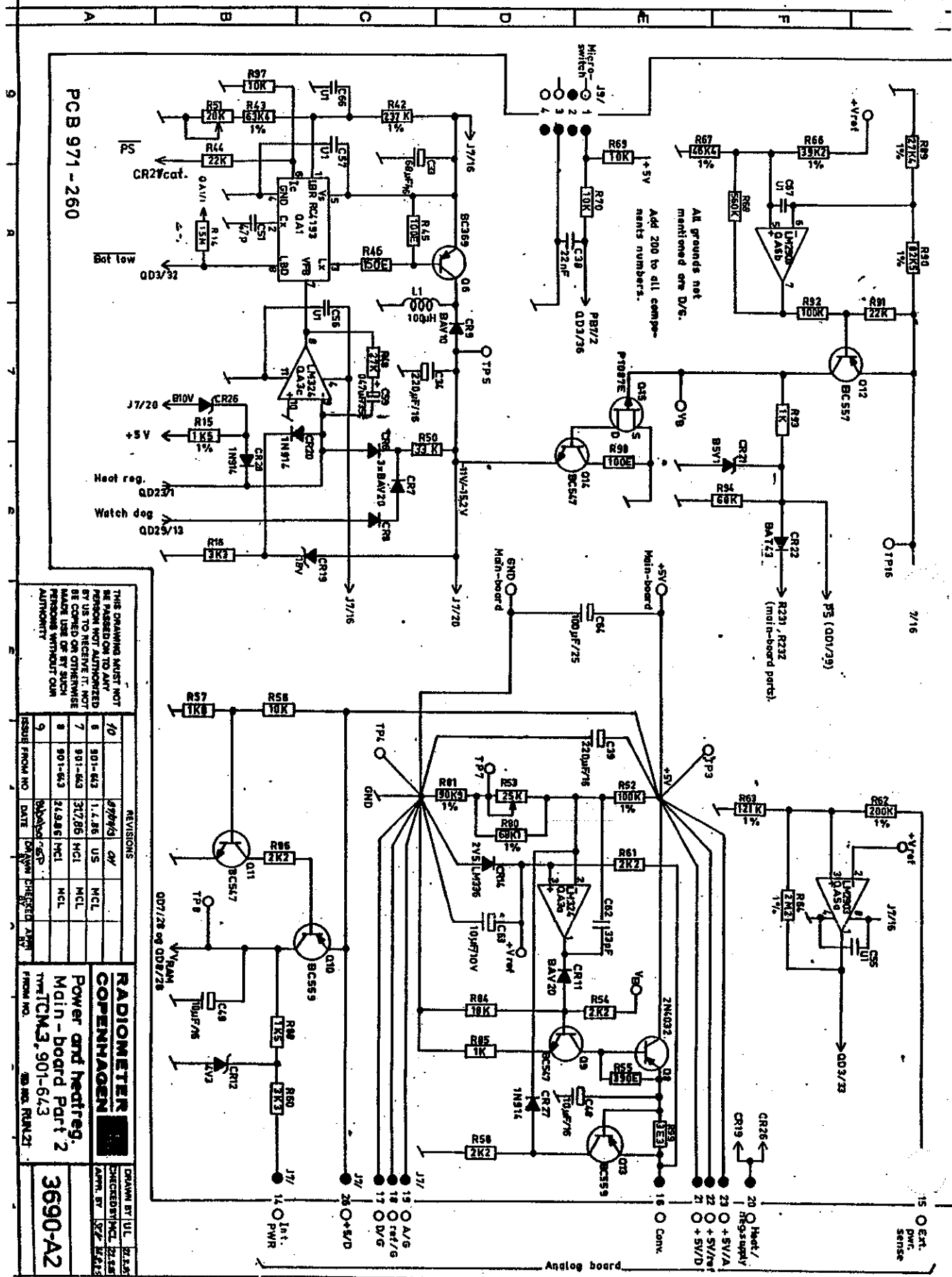
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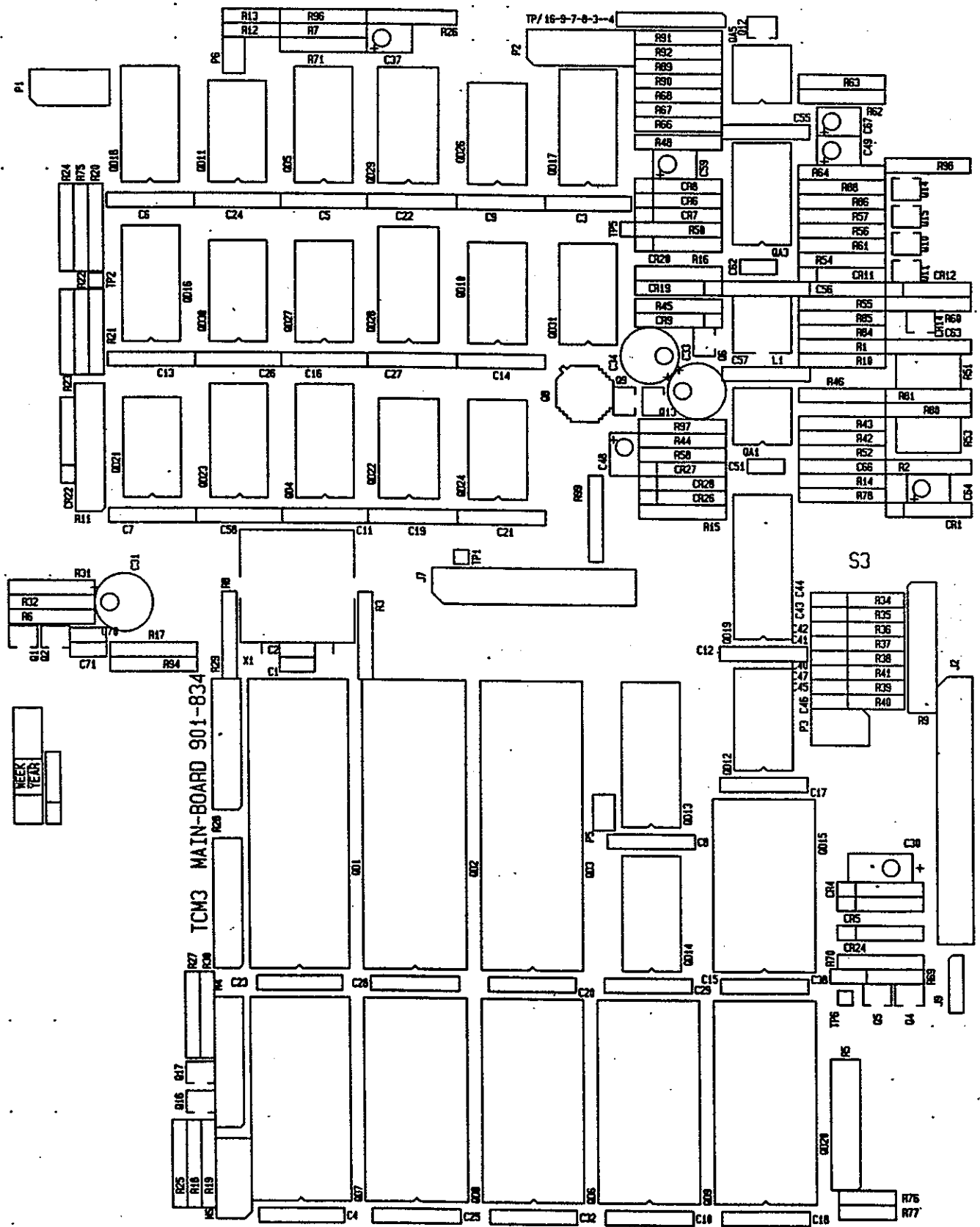
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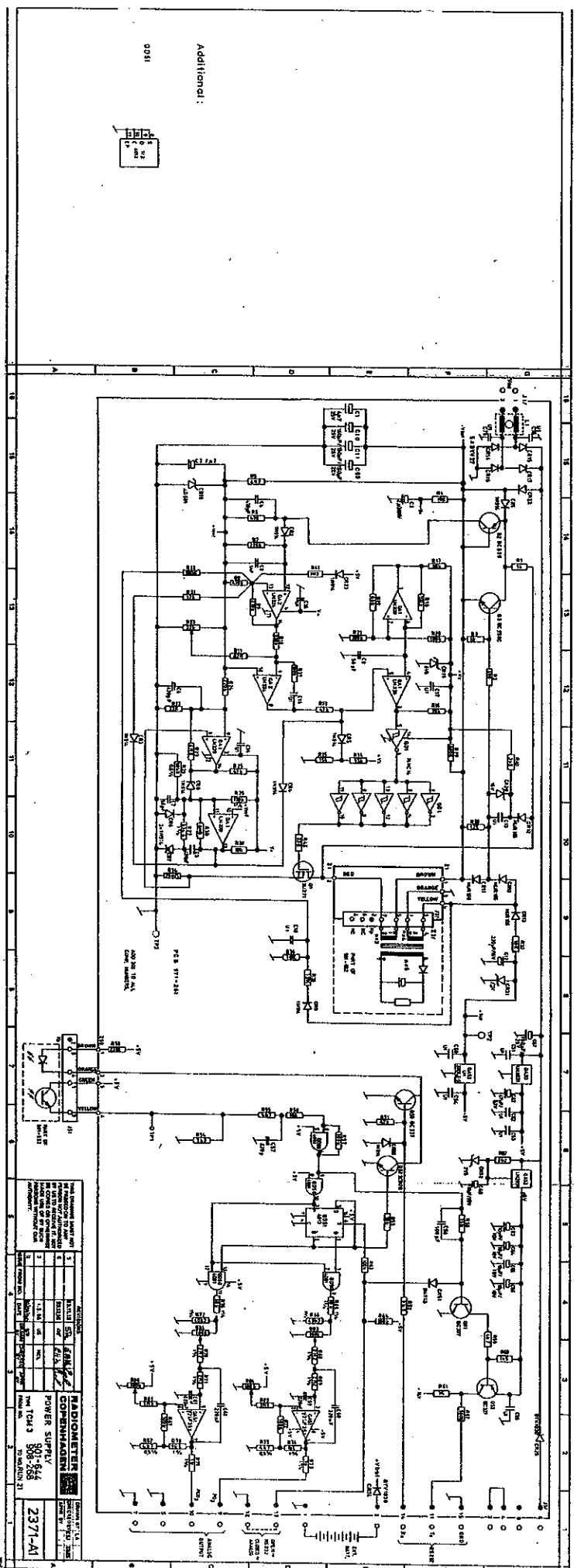




TCM3 Main PC-Board 901-834
Component Layout

Additional:

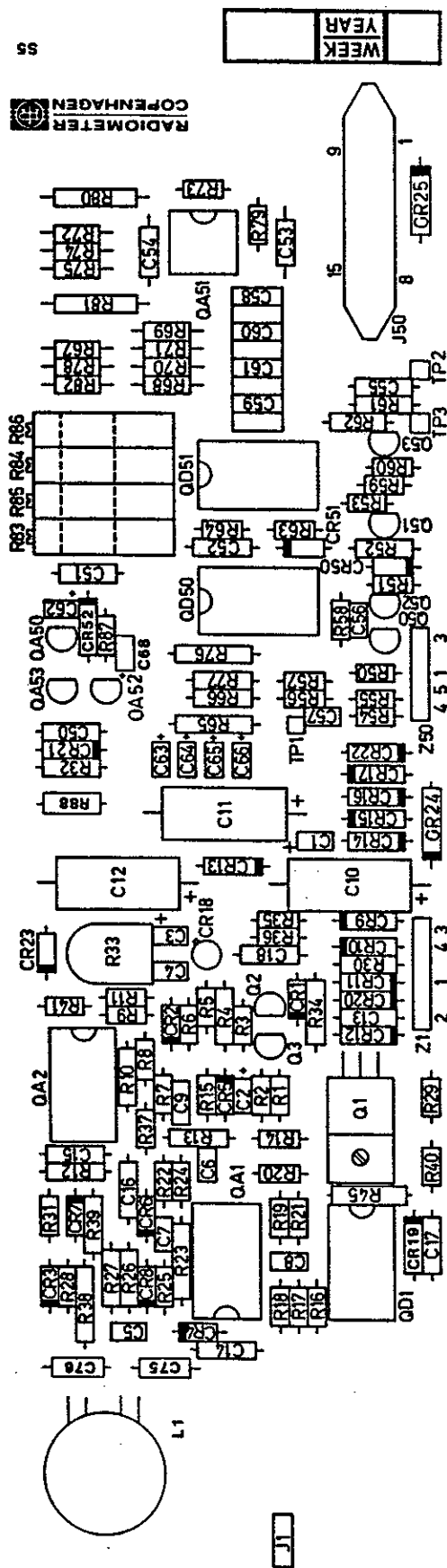
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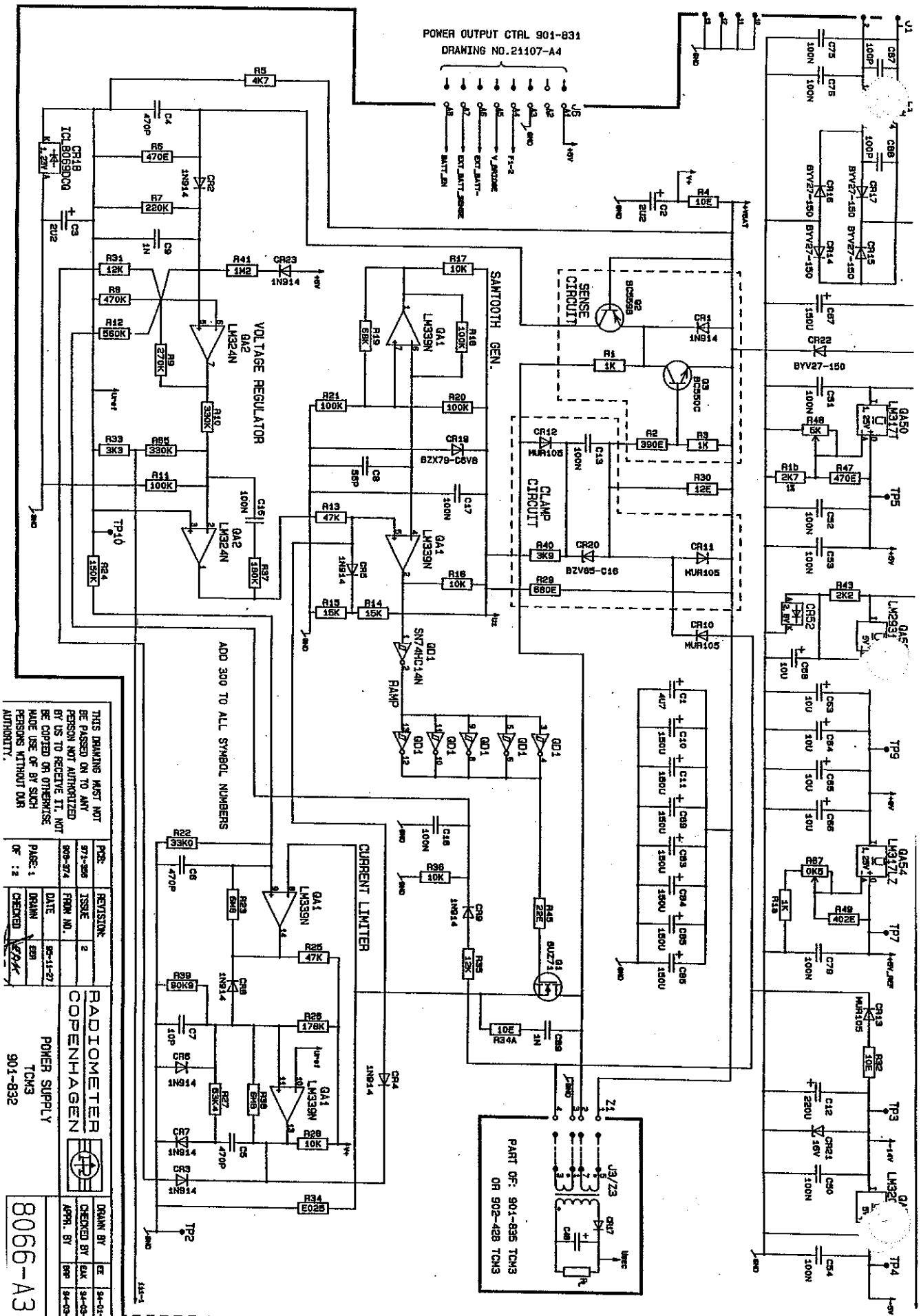


THE FOLLOWING PARTS ARE REQUIRED FOR THE CONSTRUCTION OF THIS CIRCUIT. THE PARTS LIST IS GIVEN IN THE TABLE BELOW. THE PARTS LIST IS GIVEN IN THE TABLE BELOW. THE PARTS LIST IS GIVEN IN THE TABLE BELOW.																																																																																																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

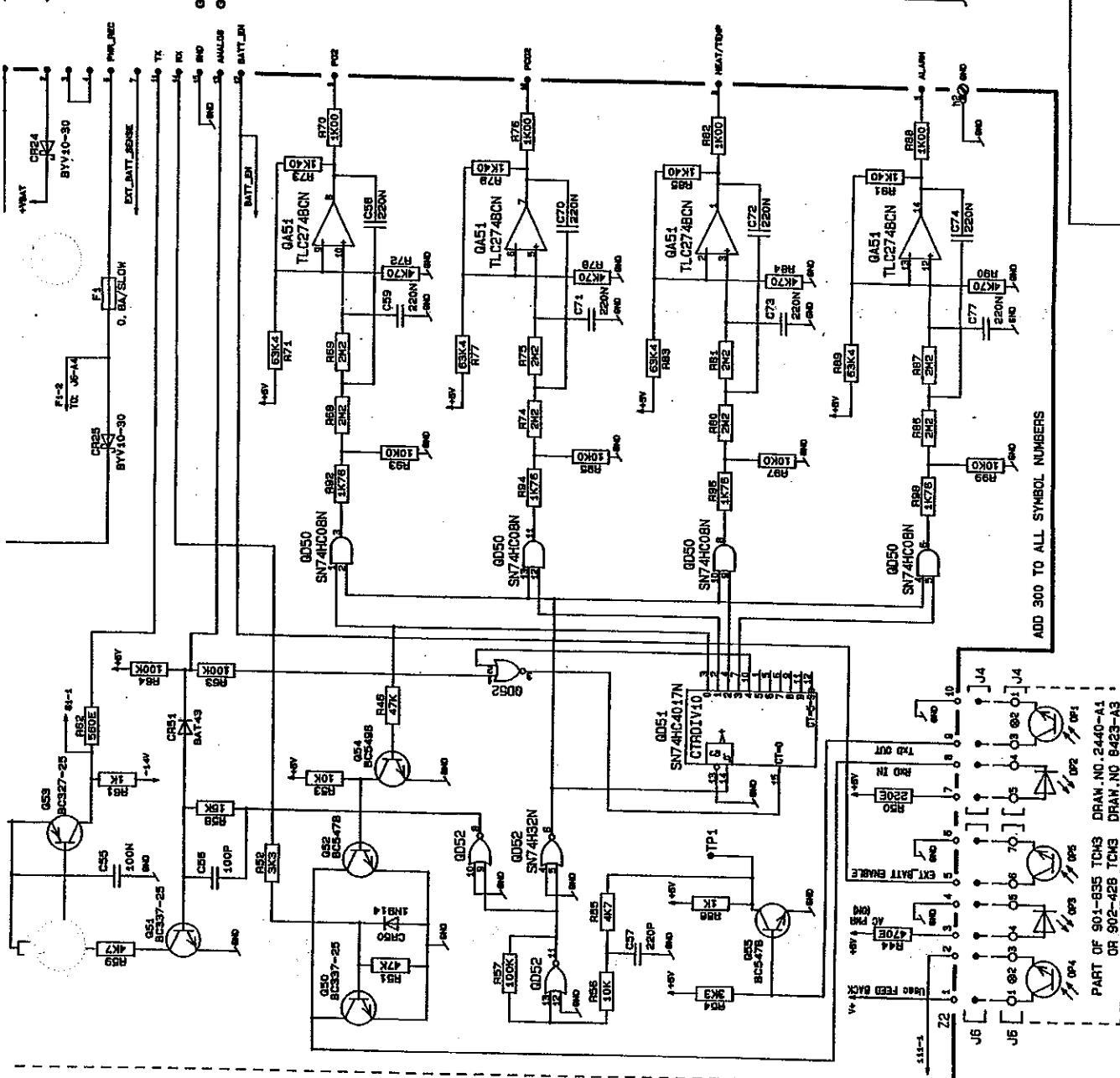
2371-A1

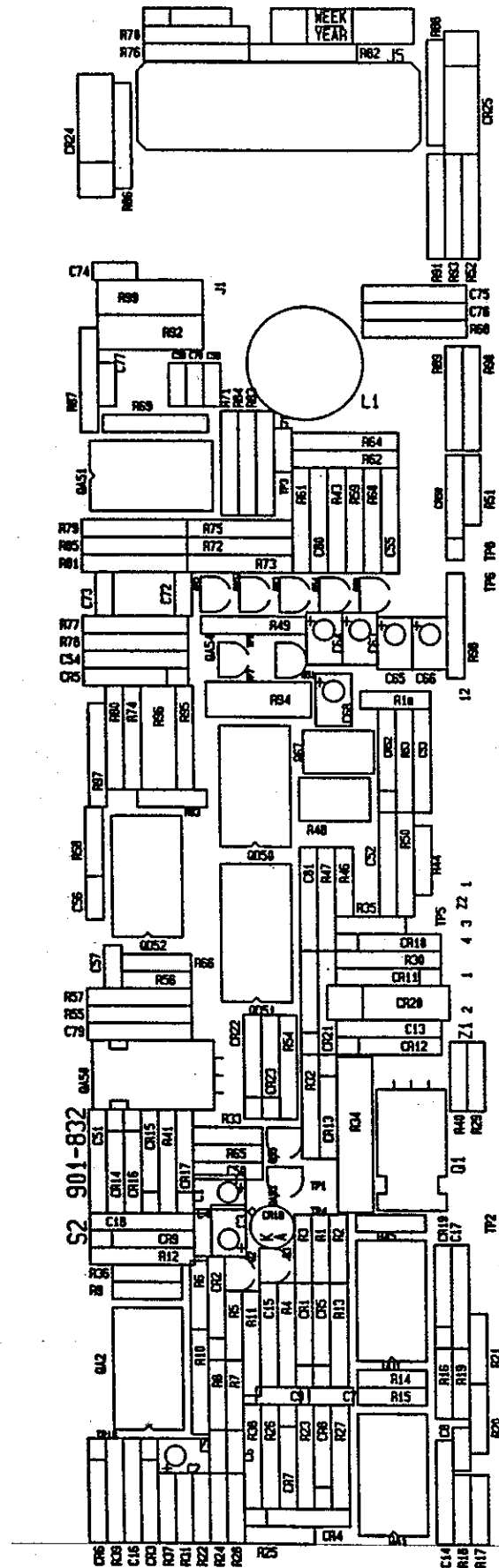
TCM3 Power Supply PC-Board 901-644
Component layout



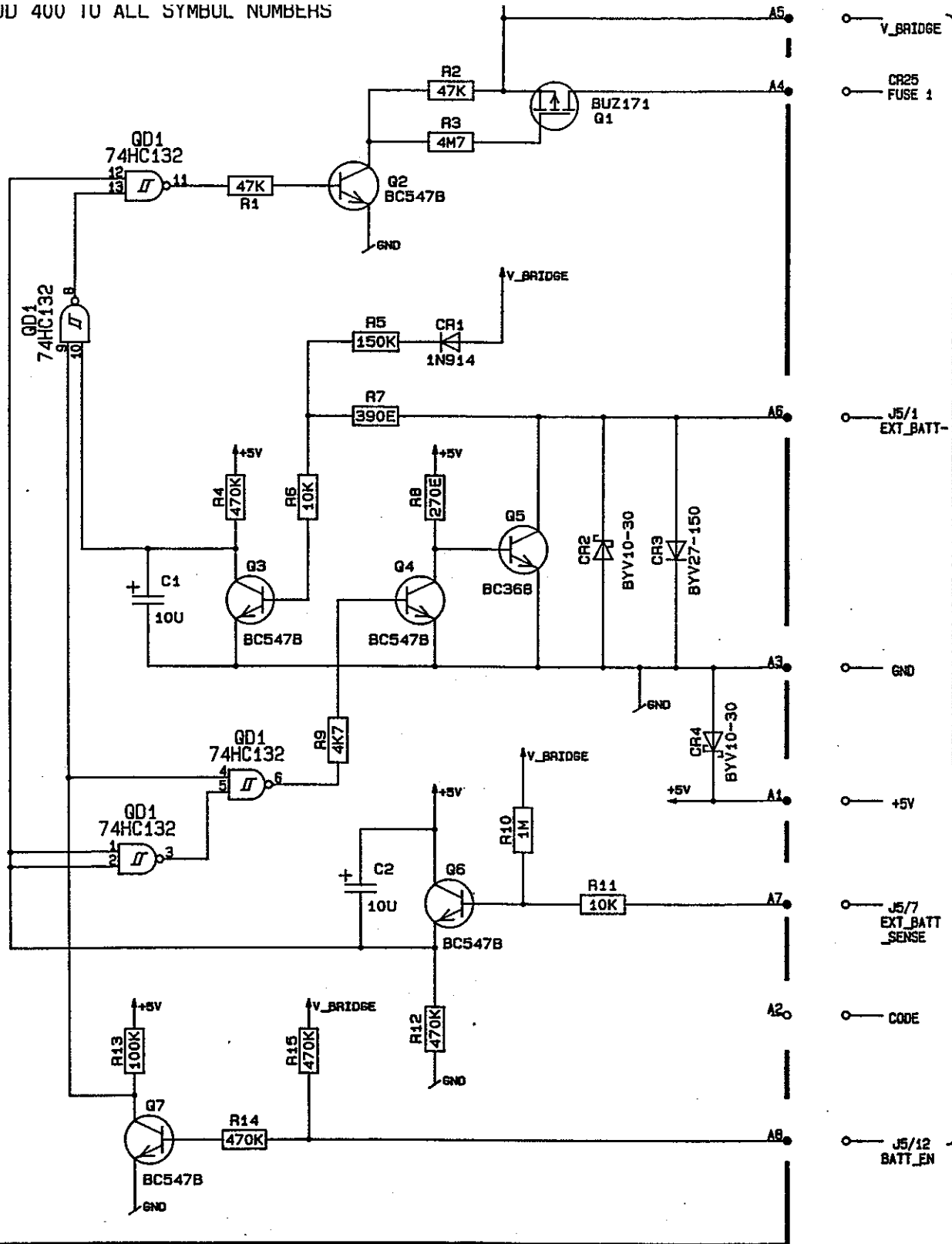


EXT
BATT.





ADD 400 TO ALL SYMBOL NUMBERS



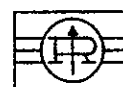
POWER SUPPLY 901-832 DRAWING NO. 8066-A3

POS.	DEVICE NAME	+5V	GND			
QD1	74HC132	14	7			

THIS DRAWING MUST NOT
BE PASSED ON TO ANY
PERSON NOT AUTHORIZED
BY US TO RECEIVE IT, NOT
BE COPIED OR OTHERWISE

PCB:	REVISION:	
971-358	ISSUE	3
908-373	FROM NO.	
	DATE	94-02-02
PAGE: 1	DRAWN	EE

RADIOMETER
COPENHAGEN

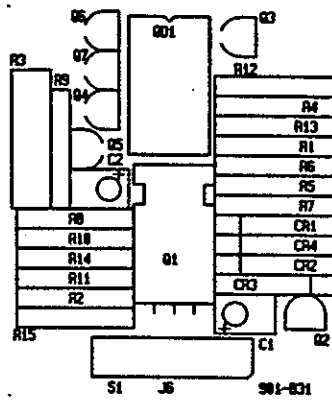


PWR OUTPUT CTRL

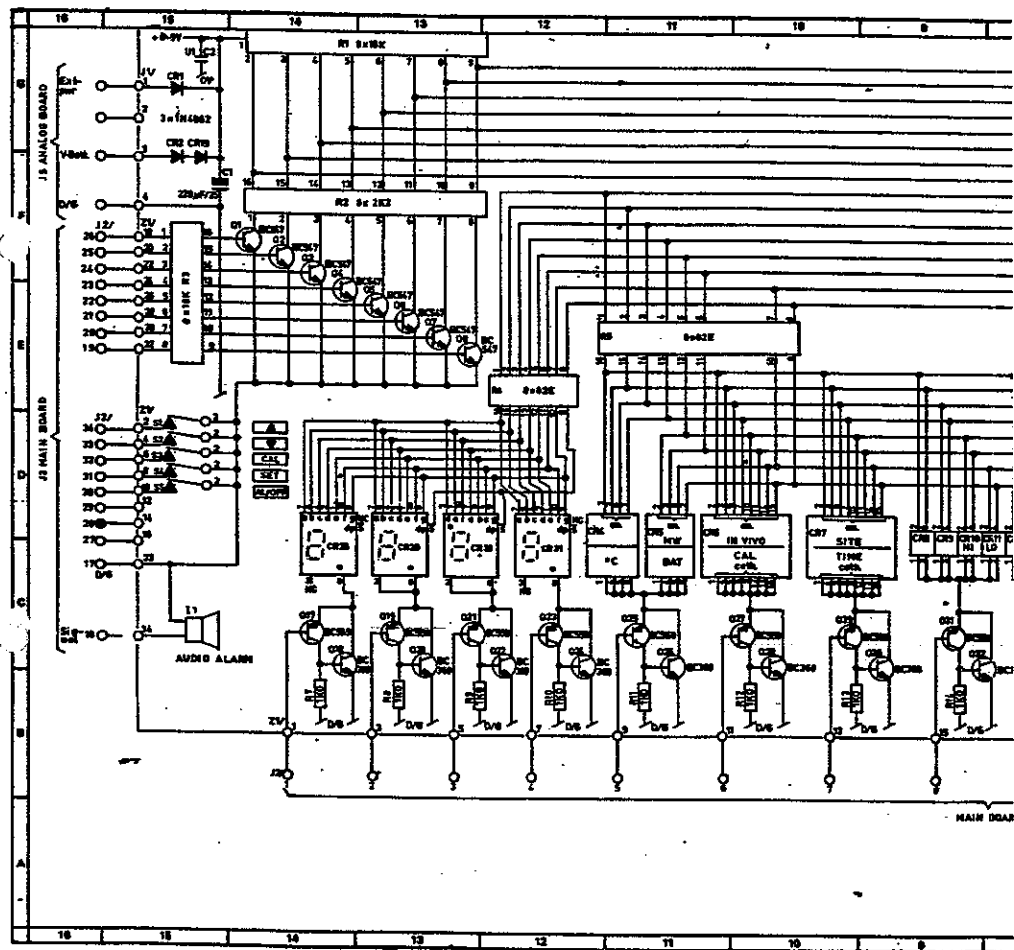
DRAWN BY	MCL	87-07-
CHECKED BY	MCL	87-07-14
APPR. BY	OLo	87-07-14

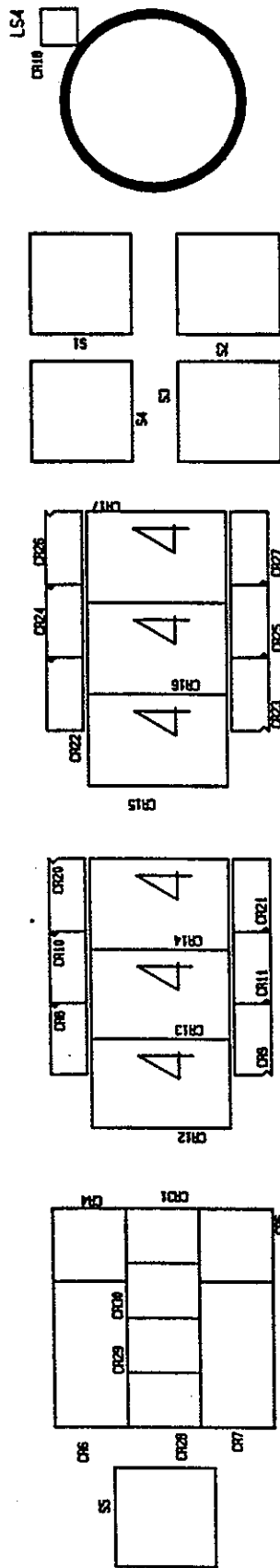
04407-11

971-358



TCM3 Output Control PC-Board 901-831
Component Layout

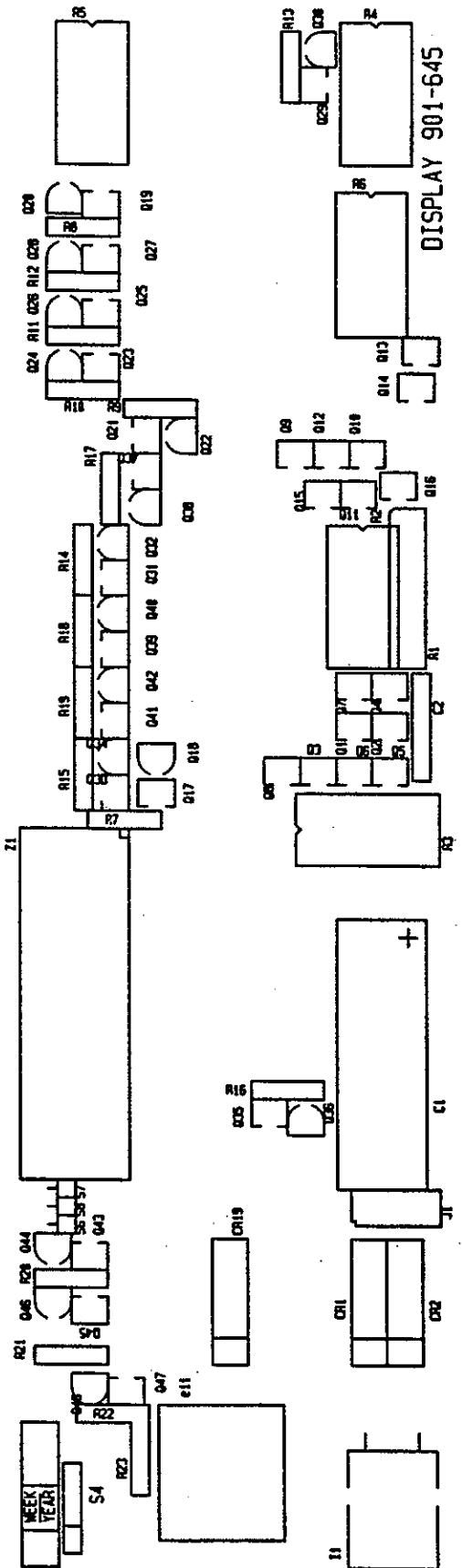




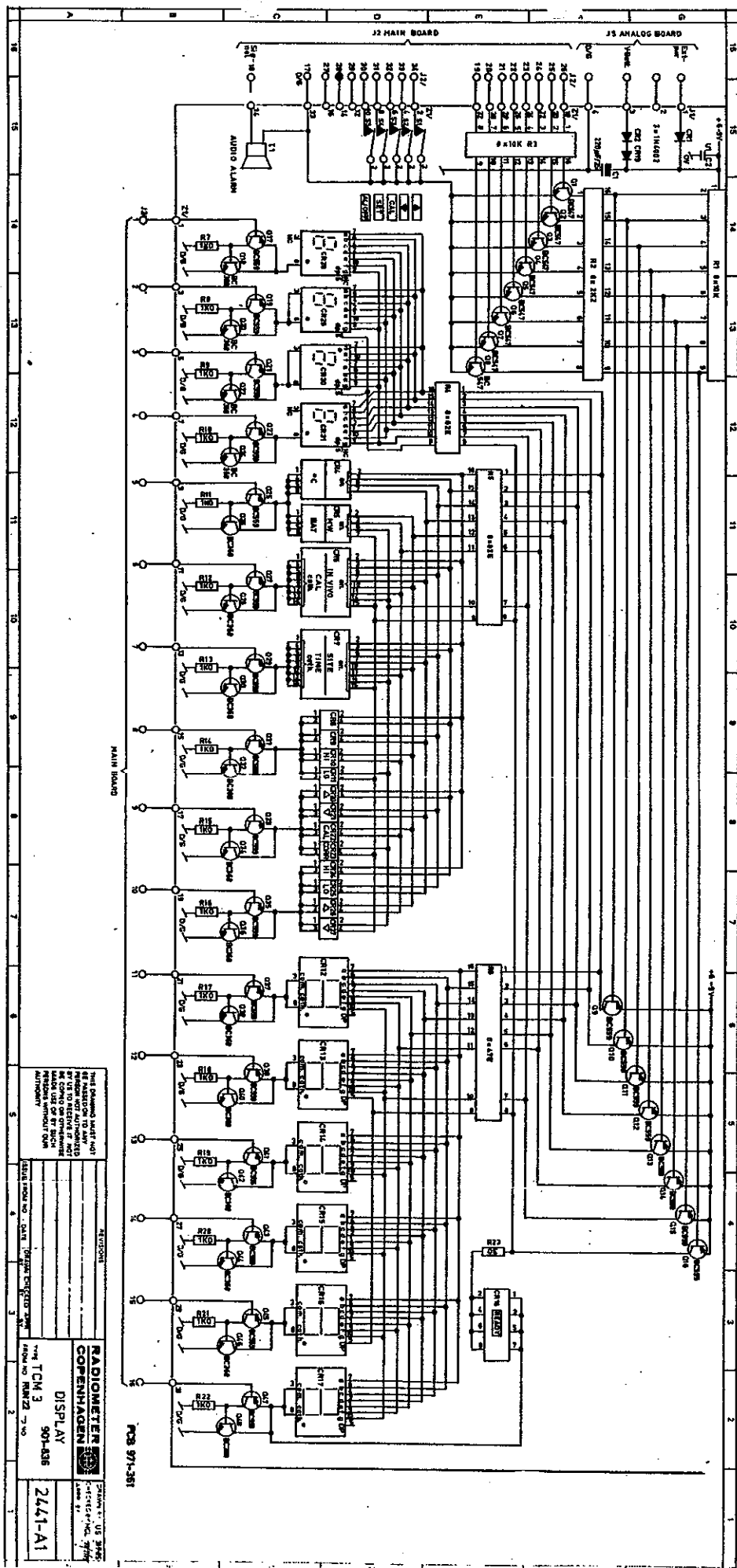
Front panel side

RADIOMETER A/S

971-262



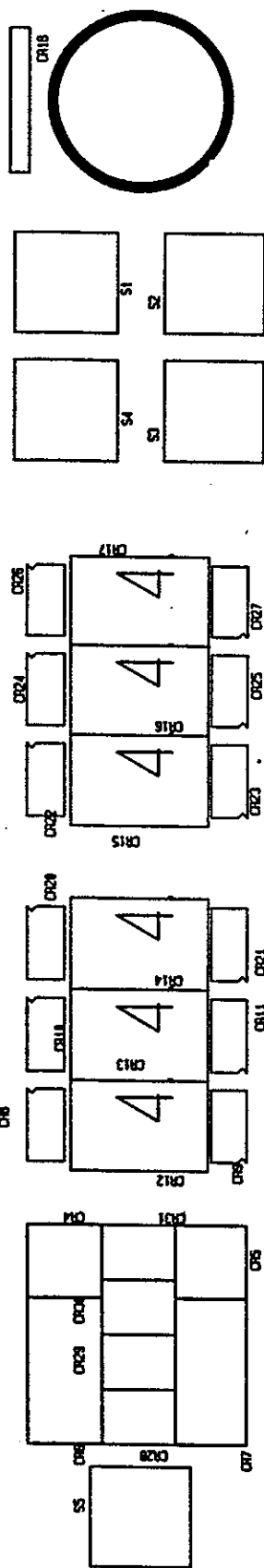
Monitor side



971-361

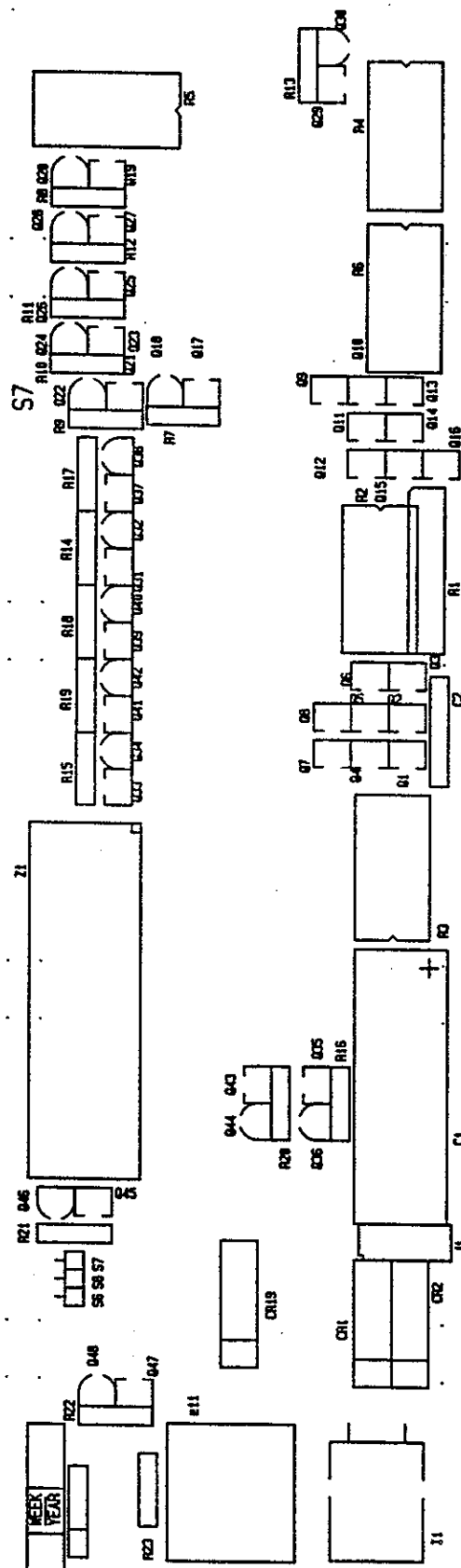
LS7

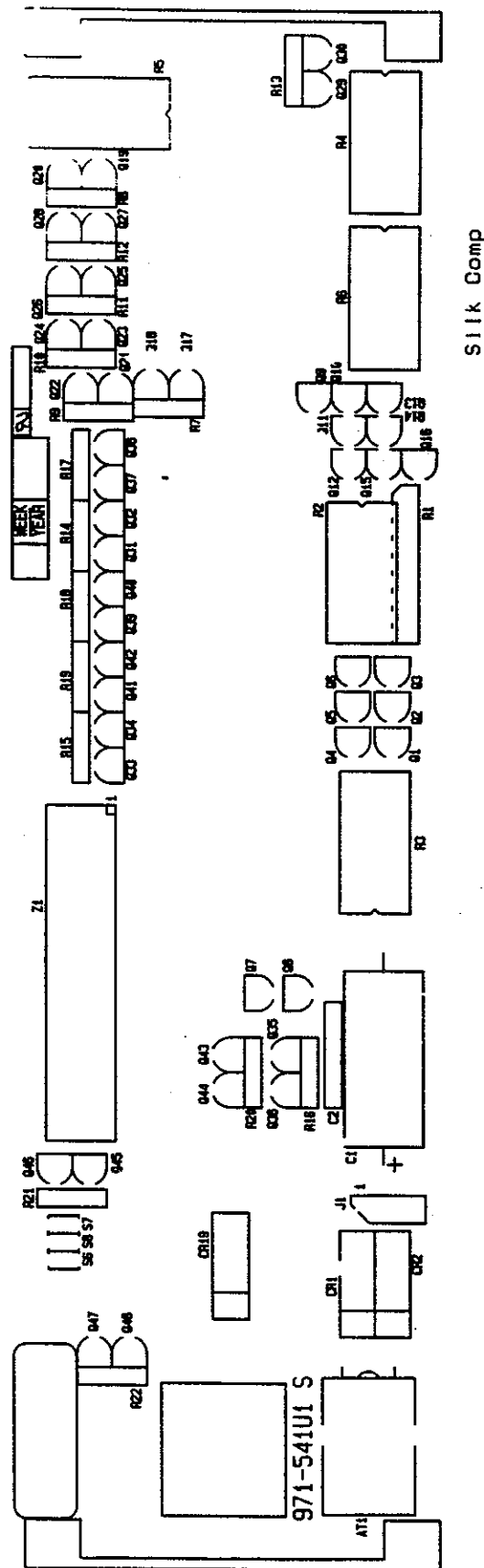
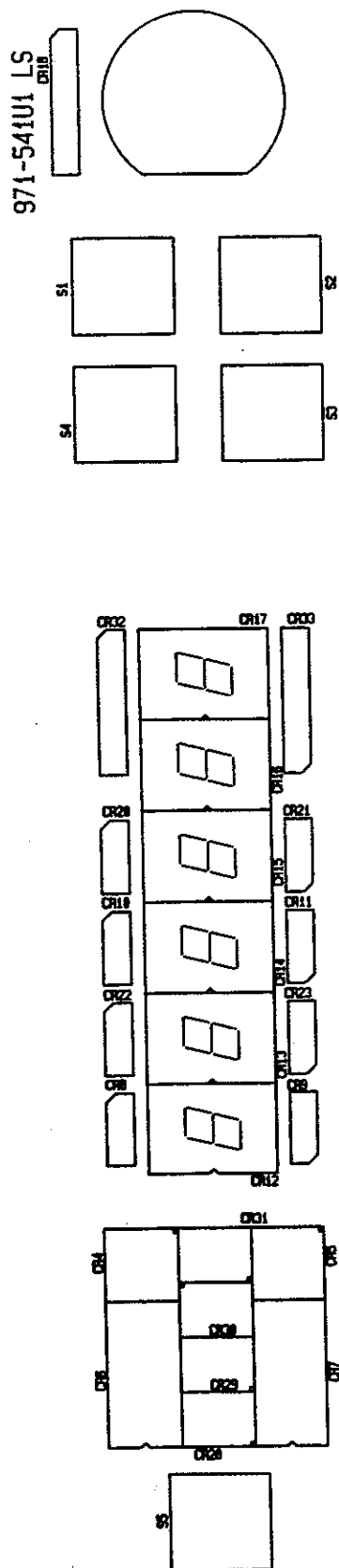
Front panel side



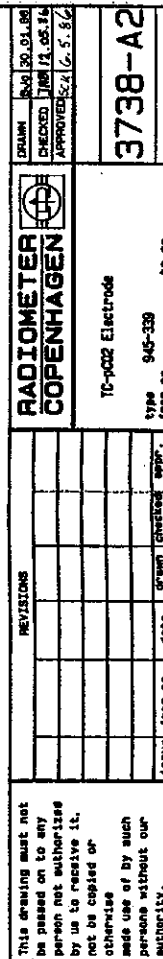
971-361 RADIOMETER A/S

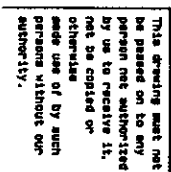
Monitor side





TCM30 Display PCB 902-470

[illegible]

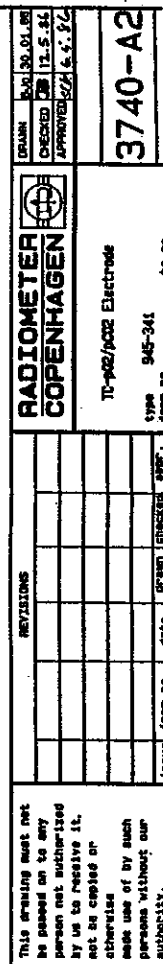


**RADIOMETER
COPENHAGEN**

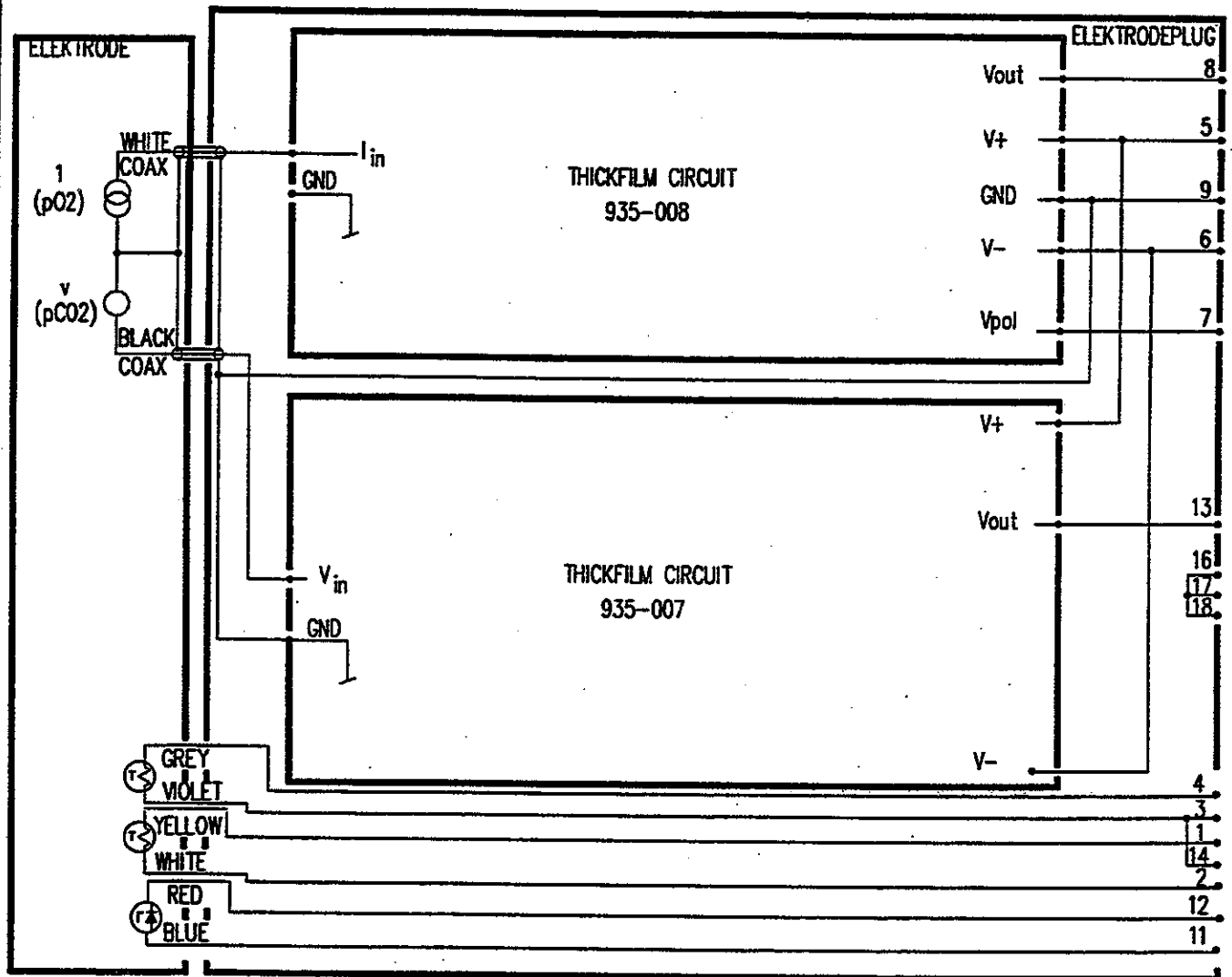
3739-A2

**RADIOMETER
COPENHAGEN**

DRAWN	20.01.08
CHECKED	20.05.06
APPROVED	26.05.06

[illegible]

Inspektionsforskrift					
N.B. Ikke-symbolmærkede egenskaber og mål skal også være overholdt					
Inspektionsform	SPC	Stikprøve	100%	Ingen	
					X
Klassifikation			Kvalitetsniveau		
Klasse	Symbol	Antal	Cp	Cpk	AQL
Kontrol	[K]				
Funktion	[F]				
Proces	[P]				
Sikkerhed	[S]		Ingen fej		
DS/ISO 2859 (MIL-STD-105)			Blanketbunden ISF		



Nominelle mål (vinklens korteste ben)		Afvigelser for mål uden toleranceangivelse					Stk.
Over	I.o.m.	Middel	Grov	Nedre	Øvre	Vinkel mål (ikke 90°)	
6	6	±0.2	±0.2	-0.03	+0.2	±1°	Matr.
30	30	±0.2	±0.5				Beh.
500	500	±0.3	±1	-0.04	+0.3	±0.5°	

RADIOMETER COPENHAGEN
Radiometer Medical A/S, Copenhagen, Denmark

tc-pO₂/pCO₂ Electrode, E5280

Målestok: Tegn. HOI 970604
Kons. JAL 970604
Godk. *[Signature]*